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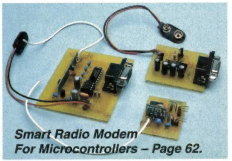

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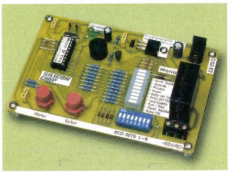

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Publisher & Editor-in-Chief
Leo Simpson, B.Bus., FAICD

Production Manager
Greg Swain, B.Sc.(Hons.)

Technical Staff
John Clarke, B.E.(Elec.)
Peter Smith
Ross Tester
Jim Rowe, B.A., B.Sc, VK2ZLO
Rick Walters

Reader Services
Ann Jenkinson

Advertising Enquiries
Leo Simpson
Phone (02) 9979 5644
Fax (02) 9979 6503

Regular Contributors
Brendan Akhurst
Rodney Champness, VK3UG
Julian Edgar, Dip.T.(Sec.), B.Ed
Mike Sheriff, B.Sc, VK2YFK
Philip Watson, MIREE, VK2ZPW
Stan Swan

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Editorial & advertising offices:
Unit 8, 101 Darley St,
Mona Vale, NSW 2103.
Postal address: PO Box 139,
Collaroy Beach, NSW 2097.
Phone (02) 9979 5644.
Fax (02) 9979 6503.
E-mail: silchip@siliconchip.com.au

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PUBLISHER'S LETTER

The valve circuit we said we would never publish

Quite some time ago, in the July 1994 issue to be precise, I wrote an editorial entitled "Valve Amplifiers Are Dead & Buried". The gist of the editorial was that valve amplifiers were far too costly and poor in performance, relative to even run-of-the-mill solid-state amplifiers. I went so far as to make the statement that "SILICON CHIP will never publish a design for hifi valve amplifier unless it is of academic interest only. In fact, let's be even more absolute and just say NEVER".

So why are we now publishing a design for a valve preamplifier? Well, as they say in politics, *never say never!* I still believe that valve amplifiers are far too expensive and that their performance is mediocre compared to very cheap solid-state designs. In fact, our high quality amplifier designs published in the intervening years since 1994 have continued to widen the gap.

That has not discouraged readers and kitset suppliers from periodically suggesting that we do a valve amplifier of some sort or other. In fact, only a month ago, one of the kitset suppliers suggested that we do a 60W valve guitar amplifier with its own speaker, etc. When they did the sums for the likely kit price (over $1000), they quickly back-pedalled.

So why do a valve preamp? Again, there have been a number of suggestions from readers and a number of circuits have been published elsewhere, all of which by the way, we have regarded as jokes. There has even been a PC motherboard with an on-board valve preamplifier for the sound section. Again, what a joke. A bad joke at that.

But having cast such aspersions, we were then more or less obliged to show we could do better. And we have. The triode preamp circuit featured in this issue is considerably better than anything we have seen published elsewhere, either recently or in the past.

The good performance comes about because of three factors, two of which were not available in the days when valves ruled. First, we have run the valve heaters from pure DC. This was sometimes done years ago but it was difficult. Now it is easy, using a 3-terminal regulator.

Second, the critical grid resistors are metal film types which have very low noise. Thirdly, and most important, our circuit has a substantial degree of negative feedback to greatly improve distortion and frequency response. It turns a very average performance into something we regard as acceptable (for valve technology, that is).

Mind you, some valve fans will turn up their noses precisely because we have used negative feedback in the circuit. Perhaps we can reassure them: the amount of applied negative feedback is still nowhere near as much as is commonly used in op amp circuits and the circuit still displays "soft clipping" when driven hard. But does it have "warm sound"? Probably not, because it does not have distortion levels of more than 1% unless it is driven to very high levels. Build it and see for yourself.

So there you are. We have changed our stance (slightly) and published a valve preamplifier. It is still a long way from publishing a high-quality valve stereo amplifier which would cost lots of money for fairly average performance and not much power.

And let us not mince words. While this mono preamp will probably sell quite well, to people wanting to satisfy their curiosity about valve circuits, its performance is still well below what can be achieved with a common low-noise op amp IC such as the LM833 which costs just a few dollars.

Leo Simpson

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Cat 1133-7	**Serial**	$469
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Cat. 8866

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Cat 1146-7	**WBT with Smart Card access**	$829
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Cat 3460-7 **Video Signal Conditioner** $169

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NEW!

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MAILBAG

Misconceptions about copying music

I'd like to raise some points regarding comments made in the October 2003 Publisher's Letter and related comments in a letter to the editor from the same issue.

The editorial questioned "Why buy a disc when you know you can't make a direct copy for your own personal use?" This implies that it is OK to copy CDs for personal use. However, whereas the USA has "fair use" provisions in their copyright laws, we do not. Under Australian copyright law you are not permitted to make copies of music for *any* purpose – personal or otherwise – unless you first secure permission from the lyric and music copyright holders and the publishers.

Using devices like MP3 players, digital jukeboxes and MD walkmen for their intended purpose is therefore technically illegal even though it's legal to market and buy them. There is some irony when a large company markets these devices and music – one arm effectively encourages the breaking of copyright law while another aggressively pursues copyright violations.

It's deplorable that ARIA continues to do nothing to address issues created by new technology while providing no assistance to consumers wishing to "do the right thing" within the confines of our outdated laws. Consumers cannot be blamed for ignoring copyright requirements in this context – it's infeasible to do otherwise.

In the same issue, correspondent Simon Kareh stated that CD-R AUDIO discs cost more than "normal" CD-Rs "... due to the royalty factor ... which makes it legal for me to copy my copyrighted audio". I don't believe this is correct. There is no legal statement on "CD-R Audio" discs (or anywhere else) which says that, through the royalty factor, their purchase grants the right to put copyrighted material on them.

Your editorial also mentioned legal challenges to copy protection overseas. I understand that these are all in the US and the basis of the challenges is that copy protection violates "fair use" copyright and "freedom of speech".

Unfortunately, since Australian law does not include either of these, any findings overseas will not be applicable here.

There is a misconception that "fair use" copyright exists in Australia. At the same time, it's frustrating that outdated copyright laws continue to be applied to new technology in often inappropriate ways. Lawmakers must be persuaded to initiate much-needed law reform so that new technology products can be legally used, but this will only happen when enough people are motivated to complain. This means that publications like SILICON CHIP should present the reality of the law rather than simply mirroring popular wisdom.

Misrepresenting the law merely gives credence to the myths which continue to be accepted unconditionally by a vast majority of Australians.

Jonathan Woithe,
via email.

Comment: you are quite correct in your view on the illegality of all copying in Australia and perhaps we should have alluded to this in the Publisher's Letter. However, let's be realistic, lots of people do it. It is the same thing with VCRs – no taping is allowed, but everyone does it. Stopping it will be impossible and if ARIA wish to keep their heads in the sand, then so be it. There have been many situations in the past where technology has made nonsense of the law and we see no reason to pompously tell people that something is illegal (it's against the law!!!) when the law is ludicrous, inequitable and unenforceable.

Until Copyright Law in Australia is changed to allow similar rights to that in the USA, it will remain a joke and most Australians will take no notice of it.

Cheap CDs do not have world-class artists

I would like to add a few comments regarding the Publisher's Letter in the October 2003 issue. Two issues were raised, namely falling CD sales and secondly the difference in price between CDs.

There are different reasons for declining CD sales. One is the fact that CDs last much longer than tape or vinyl recordings. Also when a fine music collector builds up his or her music collection there is little reason to buy another CD of the same piece. This is a different situation to that which existed before CDs, when a vinyl record was discarded after it developed too much surface noise. The degradation justified the purchase of a new LP.

For those buying pop music, the reasons are different. New singers, styles and fashion have produced, in the past, a steady "cash cow." Downloading pop music is often a financial necessity for the cash-strapped younger generation always being pressured to have the latest consumer fad. Also I have heard it said that many pop CDs only have two or three good tracks and the rest are rubbish. If that is the case, pop music enthusiasts can't be frowned upon for downloading selected tracks. Therefore both types of music have suffered, but for different reasons.

Regarding Naxos and other low-priced labels versus the expensive labels, Naxos has many excellent CDs and I have many in my collection. However, Naxos do not have internationally famous singers such as Emma Kirkby, Luciano Pavarotti etc. Large recording companies like Decca and Sony compete strongly to sign up famous artists and as such have to pay them large sums of money. This is reflected in the CD prices. If you compare the playing of Bach's Goldberg Variations from a little known pianist against Murray Perahia or the

legendary Glenn Gould, the difference is amazing. That is why serious collectors will pay two or three times as much for a CD that is going to give a lifetime of pleasure.

Sony and the other major companies also have a budget line; these are ADD recordings from the 60s and 70s. You say that "production costs for a CD, case and booklet are around a dollar or so." However the retail price of any item is many times the material cost. You must know that from publishing "SILICON CHIP."

It's not all gloom and doom however. Although CD sales are down by approximately 10%, DVD music and video sales have increased by about 126% (from Australian Record Industry Association data) in 12 months. It remains to be seen whether these sales will be affected when DVD recorders become more affordable.

As to your comment regarding the quality of MP3 vs CD, I doubt if sound quality is the prime consideration for many people. For many, but not me, I suspect convenience is the most important factor.

On a different subject, keep up the good work on electronic projects, especially those using the Picaxes.

John Hamilton,
via email.

Art approach to PC boards has benefits

I read Part I of the PC Board Design Tutorial with interest. I have designed several PC boards for manufacture over the past year – two of them reaching a bestseller list. I have also designed PC boards for five well-known electronics magazines during the year. All of these were done with a simple art program and pen and ink.

The reason for this is that I prefer the control that an art program and pen and ink give me over the design process – or perhaps I should say the different form of control they offer. They also give me an effective means of retracing my designs both conceptually and in their layout. The result, admittedly, is not as crisp as it might be but the designs are popular.

There is a place – a large place – for a more sophisticated approach and the success of some of the software alone is proof of this. In this regard, the PC Board Design Tutorial is a valuable mini-series. It gives a well written overview and no doubt concurs with the methods of most designers.

At the end of the day, I believe that what matters is that authors and magazines, designers and manufacturers, are able to "meet each other". Above all, that concept is not sacrificed for presentation, nor presentation, where it is important, for concept.

Rev. Thomas Scarborough,
Capetown, South Africa.

Comment: designing one-off boards for your own use is fine using your approach. However, all boards featured in SILICON CHIP have to be compatible with a recognised PC board program such as Protel. No local PC board manufacturer would be interested in producing it otherwise. Art programs cannot produce drilling details, etc.

DVD aspect ratios are not a problem

Am I the only one who finds something wrong with this whole discussion about DVD aspect ratios? I fail to see the problem. If you do not want to see movies filmed for the theatre in their original format, simply zoom the DVD player to full height which will simply chop off the sides of the film. After all, this is what you see on commercial TV. The reason that dual format DVDs are seldom produced is that most, if not all, DVD players have the zoom feature.

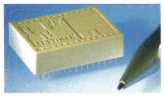
I would not call myself a purist yet I would rather see my movies in the format in which they were originally shot. I find the black bars above and below the picture a small price to pay for seeing the whole movie. It is not as if the people who designed Cinemascope et al did this to deliberately to irritate the watchers of DVD some 50 years hence. A purist is one who buys a projection TV, a surround sound system and builds a home theatre room. One who desires to see the whole picture is simply a movie lover.

John Hancock,
Morphett Vale, SA.

High definition TV has lots of advantages

I was a little disappointed at your editorial regarding digital TV in Australia. With attitudes like that it is little

The Tiger comes to Australia

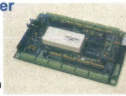


The BASIC, Tiny and Economy Tigers are sold in Australia by JED, with W98/NT software and local single board systems.

Tigers are modules running true compiled multi-tasking BASIC in a 16/32 bit core, with typically 512K bytes of FLASH (program and data) memory and 32/128/512 K bytes of RAM. The **Tiny Tiger** has four, 10 bit analog ins, lots of digital I/O, two UARTs, SPI, I²C, 1-wire, RTC and has low cost W98/NT compile, debug and download software.

JED makes four Australian boards with up to 64 screw-terminal I/O, more UARTs & LCD/keyboard support. See JED's www site for data.

TIG505 Single Board Computer



The TIG505 is an Australian SBC using the TCN1/4 or TCN4/4 Tiger processor with 512K FLASH and 128/512K RAM. It has 50 I/O lines, 2 RS232/485 ports, SPI, RTC, LCD, 4 ADC, 4 (opt.) DAC, and DataFLASH memory expansion. Various Xilinx FPGAs can add 3x 32bit quad shaft encoder, X10 or counter/timer functions. See www site for data.

$330 PC-PROM Programmer

This programmer plugs into a PC printer port and reads, writes and edits any 28 or 32-pin PROM. Comes with plug-pack, cable and software.

Also available is a multi-PROM UV eraser with timer, and a 32/32 PLCC converter.

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Ph 03 9762 3588, Fax 03 9762 5499
www.jedmicro.com.au

wonder that DTV has been "slow" to get accepted.

I have had a HD-STB for the last 12 months now and cannot crow enough about the advantages to family and friends. The picture and sound quality are truly amazing, with perfect reception (once a quality aerial and coax are used). The quality of the STB is a different issue.

The main reasons that DTV does not have greater market penetration are that 95 out of 100 people that I talk to have not even heard of DTV. STBs are very thin on the ground and sales "droids" are not trying to sell them. I don't think they yet understand the technology and are therefore scared to push the technology in case they get asked a technical question. After setting the wheels in motion and then changing the rules a bit, the government seems to have backed away from DTV.

The future is very bright for digital TV, whether it is standard definition or high definition, 5.1 surround sound or stereo and it will be the only FTA TV that you can watch in five years time! I think some positive and informative articles are well and truly needed and you have the perfect forum to get this information to the masses.

David Williams,
via email.

Comment: There is no argument about picture quality. Standard definition is pretty good and HD is even better. However, you need one for each set in the home (most people with multiple sets watch different programs). You also need another decoder for the VCR if you want to record another channel off air. This adds up to a lot of money, even if decoders have now come down a long way in price. Surround sound encoding is another issue which is yet to be properly addressed.

Digital TV looks good

I agree with Leo Simpson's Publisher's Letter in the July 2003 issue, entitled "Digital TV Is A Complete Failure" but only up to a point. Yes, the uptake and functionality of Digital TV may be slow but what he neglected to say was just how good it is.

I have worked in television (ABC) for 38 years and have seen the most incredible changes from valves to transistors, integrated circuits and digital. The change from analog to digital has seen the video signal-to-noise improve by more than 10dB. This produces noise-free pictures (>50dB S/N) for the first time.

Putting aside the technical details, I have a decoder (STB) for off-air TV digital reception and a DVD player, both connected to a wide-screen 100Hz 76cm TV. The pictures are stunning. The off-air TV signal, when showing a wide-screen movie, is as good as a DVD.

Movies that are originally film-based produce the best results. The picture quality is difficult to fault. Pictures produced from electronic cameras, such as the AFL football, do have some interesting characteristics. For example, green grass does not reproduce too well with its fine detail and tends to look like smooth carpet. It appears that there are limitations with the digital signal when it comes to some fine video detail.

In conclusion, wide-screen digital TV with standard definition is very good and I have got used to noise-free, crystal-clear pictures, with no 50Hz flicker. When I see the same picture on a 4:3 analog TV, it is way down in quality. Standard definition wide-screen digital TV is a big winner for me.

Will McGhie,
Perth, WA.

Newsgroups can be good

I am 14 years old and I have a great interest in electronics and especially robotics. Ever since I took apart my dad's old stereo when I was eight years old, I have had a fascination with anything electronic.

I have recently set up my own website (**www.cbuzz.zapto.org**) completely from scratch and I have added a discussion board for people to chat about electronics, robots and computers. I have not had much traffic yet but I disagree with some of the Editor's comments in the September 2003 issue.

I have been on many discussion boards to find answers to problems (or just to trawl for interesting info) and I can say that there isn't a whole lot of disagreeing going on. Some pages are filled with personal experiences of the same problem, which can make it a little more difficult to find your answer, but most of the time it takes under 10 minutes to find exactly what you need.

Also, there are some circuits published on these boards – not many – but I think it is a given that you use it at your own risk. The quote "definitely not to be trusted" is a bit harsh for the people who run the boards, like me. Of course, this is one person's point of view but I would like to hear some other people's comments – on my forum perhaps?

Thanks for a great magazine – I have read mine until they are dog-eared. You guys publish one of the last good magazines in *the world* that caters for everyone!

Callum Martin,
via email.

Older DVD players may not work with latest releases

I recently picked up my few-years-old DVD player from the repairer where it had been for the correction of a power supply fault. Almost as a matter of casual interest, he pointed out that this machine would not play recent DVDs, particularly productions such as "Sea Change" and "Rabbit Proof Fence" which as an Australian, I might expect to want to watch.

In the ensuing discussion, it appears that changes are constantly being made to the software applied to the DVDs which means that unless you have the latest player, you may not be able to play them at all. This is going to cause a big backlash surely. Even the despised Microsoft offers backward compatibility and keeps some reasonable semblance of control on the software updates.

Several questions arise from this: (1) Who is responsible for telling buyers that the machine they buy will work up to a certain software release? Who establishes the releases anyway?

(2) Should buyers be told whether their machines can be upgraded (apparently some can't), how it can be done (chip change, software upload) how much and whether it is covered under warranty?
(3) Should software changes have backward compatibility so that older players can play newer DVDs without the latest features?
(4) Should there be markings on both players and DVDs so that consumers can see when they buy a DVD that they might not be able to play it on the DVD player they already have at home.

While the situation may sort itself out ultimately, it could do a lot of harm to the industry. It will assist pirates since there is likely to be a market for DVDs which will run on existing players, thereby saving their owners the need to upgrade their player every year, few months, or whatever.

Bob Lions,
via email.

Comment: this looks like a nasty little problem. Can any reader throw more light on this subject?

Krypton bike light approach works with Luxeon Star

I found your May 2003 article on the Luxeon LEDs most interesting and purchased the 1W Star/O, the 5W Star V Portable and an extra collimator. As well as for general interest, I wanted to investigate the suitability of these LEDs for bicycle lighting (I often ride morning and night, in the dark), to reduce the battery size requirements.

However, while the Luxeons are indeed awesome, I was quite disappointed with the 'reach' of the LEDs. My commercial bike light with a 5W bulb totally swamps even the 5W LED (fitted with collimator) illuminated area. There was another unexpected side effect – even though you couldn't see where you were going, oncoming traffic would be blinded by the glare!

The problem is that the beam is much too divergent for my intended application, even with the collimator carefully adjusted (only a small effect). Then your September 2003 Krypton Bike Light article came to the rescue. I happened to have an old plastic lens mounted in a 50 x 50mm square plastic frame (focal length about 125mm) and placed this in front of the 1W LED (fitted with collimator). Hallelujah (to use your phrase) – by spacing the lens about 130mm from the face of the Star/O collimator, almost all of the diverging light was captured within the lens area and a bright disk of about 900mm diameter was projected onto a wall 9 metres away! The 1W LED brightness approached that of my 5W (very high quality) bulb light. The 5W Luxeon is a shoe-in.

Not only that, virtually no glare at all was evident when approaching the light, unless you enter the direct beam. Actually, this could be somewhat a disadvantage as well. The light is almost invisible from only a few degrees off-axis, whereas my commercial light throws a narrow rectangular horizontal beam together with low intensity side lobes to provide visibility for traffic approaching from the side.

Another disadvantage – the lens used creates the need for an excessively long housing but a shorter focal length lens may diffuse the beam too much (a long focal length 3-dioptre inspection lamp lens created a much smaller spot at 9 metres). Anyway, food for thought. By the way, my bike weighs in at 7.5kg, so a 1.4kg battery pack is a bit out of proportion!

Ian Thompson,
Duncraig, WA.

Halogen lighting is very questionable

With reference to the Publisher's Letter in the June 2003 issue, it was gratifying to see someone publicly air the negative side to those wretched domestic halogen lights. I was beginning to think I was the only one who detested them. It is hard to understand their popularity unless the industry has been pushing them as giving better lighting (very questionable), chic (why?), safer (how? – possibly the reverse) and more economical (rubbish).

Still, they seem to be the done thing: when my new house was built about three years ago, the electrician seemed quite taken aback when I insisted on *not* having lots of those piercing little spotlights and a ceiling full of transformers! As you point out, the waste heat from these needlessly complicated setups must at times be enough to affect the comfort of the house occupants. This does seem perverse at a time when authorities are insisting on declared energy ratings for domestic appliances and increased insulation for hot water systems, and when even such relatively small wastage as the stand-by power used by TVs, VCRs, etc has been questioned.

Brian Wallace,
Dora Creek, NSW.

SC480 amplifier is great

I wish to compliment you on the new SC480 amplifier design in the January & February 2003 issues. I have put together a stereo amplifier and am completely satisfied with the result. The sound is detailed, clear and "musical", and with no input signal it is completely silent at full volume.

Through speakers it is good but even better through headphones using a resistor network to give 120Ω impedance.

Rob Rein,
via email.

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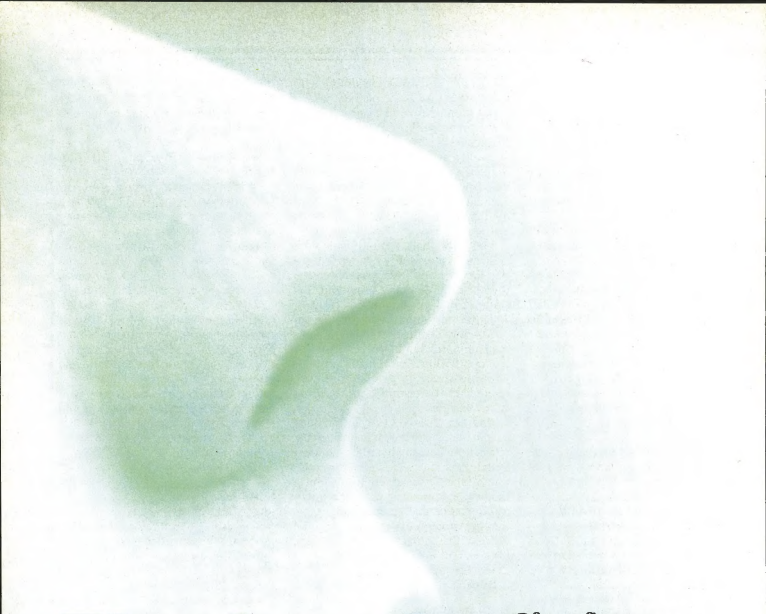


Electronic Noses Smell a Big Future

Of our five senses – sight, sound, touch, smell and taste, the first three are physical in nature. They also have readily available electronic equivalents. You can buy cameras, microphones and pressure sensors off the shelf to convert light, sound and pressure into electrical signals. Soon, smell sensors will be readily available too.

By PETER HOLTHAM

Smell and taste are chemical senses, so-called because they detect the presence of different chemicals as molecules in the air (smell) or dissolved in liquids (taste). At present, electronic sensors for both are in their infancy.

Smells are simply chemical molecules small enough and light enough to vaporise into the air. A smell may be just one type of molecule or a mixture of many different types. Over 600 different molecules wafting into your nose make up the delicious aroma of fresh coffee, for example.

Smell is a vital part of our daily lives and it uses more of the brain than any of the other senses. Smell lets us sample our surroundings and check for danger. Think of the smell of smoke, for example. Molecules of smoke can travel long distances on the wind, showing that smell can act as an early warning system.

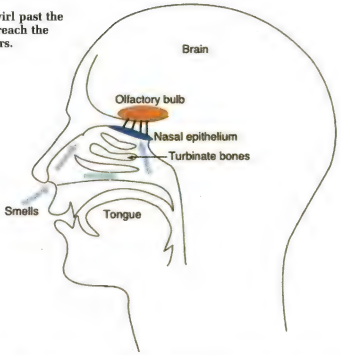
Even though the human sense of smell is poor compared with many animals, we can easily detect just parts per billion of the toxic gas hydrogen sulphide – the smell of rotten eggs. With training and experience, human noses can check products such as wine, cheese, fish and many other foodstuffs, for quality and freshness. Doctors can diagnose certain diseases from their smell alone.

Human noses are sensitive and self-repairing but they are not suited to boring or repetitive tasks. They are also subjective, prone to catching colds and cannot be used to check situations that may be hazardous. Humans cannot smell the fatal presence of carbon monoxide, for example. What we need is an electronic or E-nose, to give an objective readout of the smell-scape that surrounds us.

Scientists have been working on E-nose development since the 1980s, their first step being to understand how our biological sense of smell works. How do volatile odour molecules reaching your nose trigger recognition of a smell in your brain?

The Biological Nose

Sniffing sucks a sample of air carrying a smell into your nostrils. A mucus layer on their inner surfaces together with a forest of sticky hairs cleans the air of any stray dust particles. The filtered air swirls past the turbinate bones to the roof of each nostril. Here, just below and behind the eyes, lies the nasal epithelium containing about 5 million smell sensor cells.



Smell molecules swirl past the turbinate bones to reach the human smell sensors.

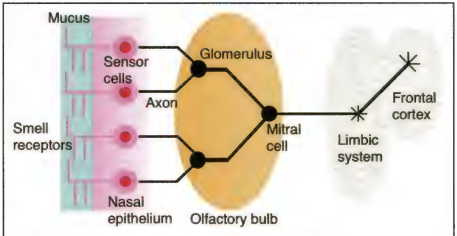
By comparison, the super-sensitive noses of dogs contain over 100 million sensors.

At one end of each sensor cell there are 10 to 20 hair-like smell receptors, bathed in watery mucus. Smell molecules attach to the receptor proteins in the hairs, triggering a cascade of chemical reactions inside the cell. The reactions result in the transfer of sodium ions across the cell membrane in a form of biological amplification.

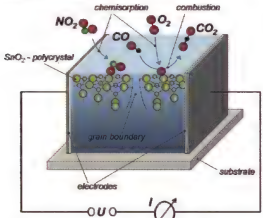
At the other end of the sensor cell there is a connecting nerve or 'wire' called an axon. The sodium ions pour into the axon, triggering it to fire with an electrical impulse. Chemical information is now an electrical signal on its way to the brain for identification.

Bundles of axons from groups of sensors thread their way through holes in the base of the skull. The bundles terminate in two olfactory bulbs, one in each nasal cavity. Inside the bulbs, a cluster of neural networks called glomeruli carry out some signal pre-processing. They function much like Internet routers, sending the electrical impulses for specific smells via mitral cells to the brain.

The architecture of the olfactory bulbs results in a 1000 to 1 convergence between individual sensors and the mitral cells. A lot of information about individual sensors gets thrown away but sensitivity increases since contributions from many sensors are



Simplified diagram of the biological smell sensing system.



In a conductivity sensor the resistance of the sensing layer changes when a molecule reacts on the surface.

added together.

Final signal processing occurs deep in ancient parts of the brain concerned with motivation, emotion and certain types of memory. Actual identification of the smell occurs in the brain's more modern frontal cortex.

E-Noses

Electronic nose designers are following Nature's plan. They use a sampling device to act as nostrils and an array of chemical sensors to mimic the olfactory epithelium. Signal processing hardware and software takes the place of the olfactory bulbs and the brain.

The difficulty lies in the sensor stage. Until recently the only way to analyse a sample of air was by using complex and expensive laboratory-based instruments such as gas chromatographs. Routine analysis of smells with this technology is out of the question. But now new smell sensor technologies based on conductivity or resonance are beginning to appear. If they can be integrated into low cost chips or modules, E-noses will start to appear everywhere smell detection is important.

Conductivity Sensors

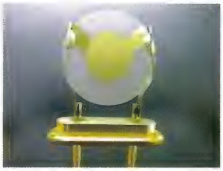
There are two types of conductivity sensor: metal oxide and polymer. Both show a change in resistance when exposed to odour molecules. Thick film metal oxide gas sensors (TGS) have been around since the late 1960s; you can buy them off the shelf from component retailers. They are sintered n-type bulk semiconductor devices made of tin dioxide. The sensor changes in resistance in the presence of gases such as hydrogen, carbon monoxide, methane, propane etc.

Just 0.1% propane by volume is enough to decrease the resistance of a TGS gas sensor up to 20 times. This concentration is well below the explosive limit for propane.

The trouble with metal oxide sensors is that they are not particularly selective and are easily poisoned, especially by sulphur compounds. They also need a continuous power supply of over 500mW to heat up the sensor. Nevertheless, they have found wide use as gas leak detectors.

Thin film metal oxide sensors using silicon micro machining methods are now starting to appear. They use oxides of tin, zinc, titanium and iridium, doped with catalysts such as platinum and palladium. A micro hotplate structure reduces heater power by a factor of 10, compared with thick film devices. Because thin film sensors are now being made in high volumes (1000-2000 per silicon wafer) the cost per sensor is falling rapidly.

A second type of conductivity sensor is based on polymers. Cyrano Sciences uses this technology in its "Cyranose 320 handheld electronic nose".



The AppliedSensor quartz crystal microbalance sensor. The diameter of the crystal is 6 mm.

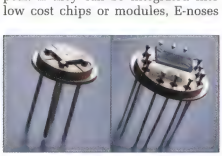
Conductive carbon black is blended homogeneously with different non-conducting polymers. The different blends are deposited between pairs of electrodes as thin films on an alumina substrate. The result is an array of typically up to 32 chemiresistors.

When odour molecules come into contact with the resistors, the polymers act like a sponge and 'swell up'. Swelling progressively breaks carbon black pathways and the resistances increase.

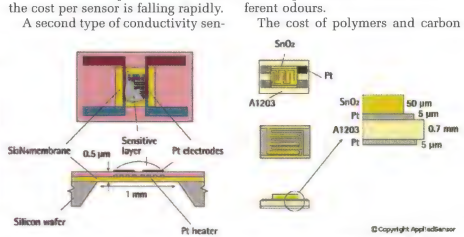
Once the smell goes away, the polymers 'dry out' and shrink, the conductive pathways rejoin and the resistances decrease. The ratio of the smell-on to smell-off resistances becomes the output of the sensor array.

Any individual sensor responds to a variety of odour molecules. By varying the amount of carbon black in the polymer or the polymer itself, an array of sensors can be built to yield a distinct pattern of resistances for different odours.

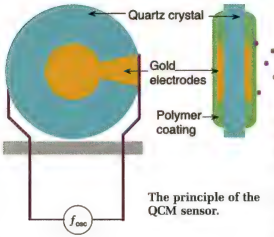
The cost of polymers and carbon



Conductivity sensors manufactured by AppliedSensor (www.AppliedSensor.com) – micro sensor (left) and thick film sensor (right) .



Internal details of the AppliedSensor micro conductivity sensor (left) and thick film conductivity sensor (right).



The principle of the QCM sensor.

black is low and the electronic interface is simple, making this ideal portable E-nose technology. An array of 32 sensors per chip is a long way short of human sensing capability but still allows reliable smell recognition with suitable software.

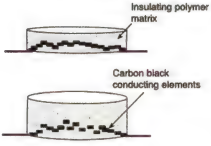
Piezoelectric Sensors

This family of sensors also has two members: quartz crystal microbalance (QCM) and surface acoustic wave (SAW) devices. QCM types consist of a quartz crystal disk a few millimetres in diameter with metal electrodes on each face. The QCM resonates at a frequency in the range 10-30MHz when excited by an oscillator.

During manufacture, a thin polymer coating is applied to one face to act as the sensing material. Odour molecules adsorb onto the polymer, increasing the mass of the QCM and reducing its resonant frequency. QCMs can detect mass changes of as little as one picogram. That amount of methane in a one-litre container gives a concentration of just 1.4 parts per billion.

QCMs can be made to respond to different smells simply by changing the polymer coating but they are most sensitive to volatile organic compounds.

The Surface Acoustic Wave (SAW) sensor is a cousin of the QCM, operating at a much higher frequency. An AC signal applied to the input creates an acoustic wave that 'surfs' over the surface of the sensor to the output. Although the AC signal is recreated at the output, it is shifted in phase. The phase shift depends on the mass of the sensing polymer layer covering the sensor substrate. This in turns depends on the odour molecules absorbed.



Polymer sensor principle.

A typical SAW sensor operates at 400MHz but its sensitivity is similar to the QCM. Because SAW devices can be made using standard semiconductor technology, they are cheaper than QCMs.

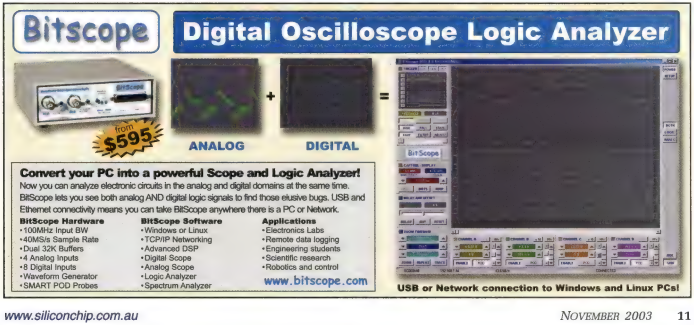
The Electronic Sensor Technology zNose® using fast gas chromatography with a SAW sensor.

An American company called Electronic Sensor Technology has already developed the zNose, which combines fast (10 seconds) gas chromatography with a SAW sensor. The main disadvantage of this family is that more complex electronics are needed compared with conductivity sensors.

Mosfet Sensors

Metal oxide silicon field effect transistors (Mosfets) can be also used as odour detectors. The gate electrode is coated with a catalyst such as platinum and exposed to the air through a window. Smell molecules react with the gate, altering the gate charge and thereby varying the conductivity of the device.

The gate and drain of the transistor are connected together to form a 2-terminal device. The voltage (around 2V) at constant current (100μA) is recorded as the sensor response to



The Cyranose® 320 portable E-nose manufactured by Cyrano Sciences (www.cyranosciences.com), photo courtesy of Cyrano Sciences.

the smell. These sensors respond to gases like hydrogen, hydrocarbons, ammonia and carbon monoxide.

With a silicon carbide substrate instead of plain silicon, Mosfets can operate at temperatures up to 600°C, as in car exhausts, for example.

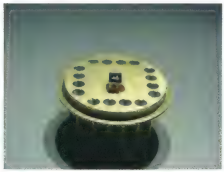
Processing the Signals

Sensors are just part of the E-nose story. Adding the electronic equivalent of olfactory bulbs and the brain turns the raw sensor data into a recognised smell. Two stages are normally required: signal pro-cessing and pattern recognition.

Signal processing compensates for baseline drift and reduces sample-to-sample variation. The signals from an array are often also scaled or normalised to cover a similar range.

Pattern recognition is the crucial step in identifying a smell from the processed data. Firstly, extracting some features from the data reduces the dimensions of the measurement space. Consider the 32 outputs of a conductive polymer sensor chip. The measurement space will have 32 dimensions. This can cause problems in analysis of the responses, not the least of which for humans is trying to visualise a 32-dimensional hyper-space.

Often the sensor responses will overlap, so there is a lot of redundancy in the 32 dimensions. Complex mathematics are used to project the 32 onto a smaller space, preferably in two or three dimensions which can be visualised by humans.



An AppliedSensor 1.5mm x 1.5mm MOSFET sensor chip on a TO8 header.

Once in a lower dimensional space, the odour pattern can be classified by comparison with known smell responses stored in a database. Here again, complex mathematical techniques such as artificial neural networks are used. These ensure that an unknown smell is matched to the most likely known smell in the database, even if the match is less than perfect.

Applications

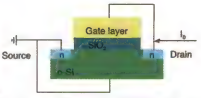
With new chip level sensors becoming available and abundant computing power to process the responses, where are the E-nose applications? The answer is almost everywhere, your car could soon have several, your home several more.

A silicon carbide Mosfet exhaust gas sensor can respond fast enough to monitor the air-fuel ratio of individual cylinders in a car.

Thin-film conductivity sensors will soon be monitoring cabin air quality, opening and closing fresh air vents as required.

In the home, sensors will also monitor air quality, sniffing out carbon monoxide, an early indicator of a fire.

One day soon they might find their way into your coffee machine to check that your morning cup is just the way you want it.



The AppliedSensor MOSFET sensor construction.

E-noses are finding widespread use in the food and drink industry. Customers rely on aroma as an indicator of the quality of the food they buy. E-noses are already monitoring the exact ripeness of fruit and vegetables and the quality of fish, cheese, meat and many other foods.

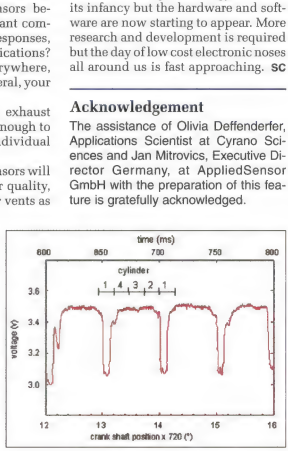
Doctors have used smell as a diagnostic tool for centuries. Commercial E-noses are already being tested for rapid diagnosis of lung cancer. They are also being used to screen bacterial cultures for early detection of lethal bugs.

Recent events have made everyone aware of terrorism. A major force behind E-nose development in the USA is the need to replace sniffer dogs checking for explosives.

Smell sensing technology is still in its infancy but the hardware and software are now starting to appear. More research and development is required but the day of low cost electronic noses all around us is fast approaching. **SC**

Acknowledgement

The assistance of Olivia Deffenderfer, Applications Scientist at Cyrano Sciences and Jan Mitrovics, Executive Director Germany, at AppliedSensor GmbH with the preparation of this feature is gratefully acknowledged.



The response of an AppliedSensor MOSFET sensor to exhaust gas composition, showing gas from individual cylinders.

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Logging your every driving moment

Some airbag controllers do more than just trigger the bags! – by Julian Edgar

Did you know that the airbag control module in your car could be constantly logging a range of driving factors – including your speed? If the proliferation of speed cameras and red-light cameras isn't enough to make you drive carefully, perhaps that piece of news just might!

CONSIDER THIS SCENARIO – you've just collided with the back of another car because you weren't paying attention. However, you won't be able to claim that you were braking hard if an electronic record shows that you didn't begin to slow down until the moment of impact. Or perhaps you were speeding? Once again, the electronic record will reveal all to crash investigators.

Convicted by your car? – it's more than just a possibility, with one such case having already occurred in the US. There, a driver involved in a double fatality claimed he had been travelling at about 100km/h. However, the electronic record logged by his vehicle's airbag showed that his speed just five seconds before impact was, in fact, 184km/h!

So what data is logged and why is it recorded? Do all airbag-equipped cars have this facility? How can you read it? And who owns the information?

The implications – not only for drivers but also for insurance companies, the police, car rental companies and fleet owners – are profound. But if the thought of your car logging your driving behaviour horrifies you, here's a let-off – at least for the time being. At this stage, General Motors in the US appears to be the only car company that's wholeheartedly embracing the technology.

In fact, GM is publicly releasing details on their systems and also working with a third party provider to make available a dedicated data reader for general purchase.

The potential benefits of Event Data Logging (EDL) has also resulted in strong US Government support for adopting universal standards for such systems. In other words, due to the influence of US legislation on car makers, it's probably only a matter of time before all cars have Event Data Logging recorded in a standard format that can be easily read.

Automotive logging

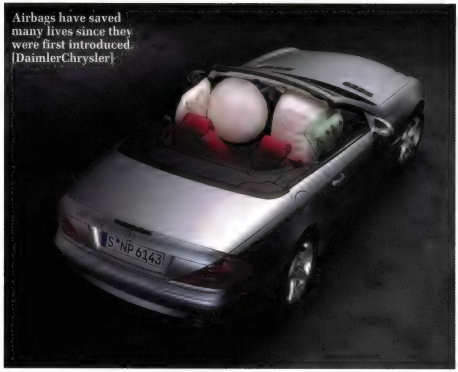
About 20 years ago, the fuel and ignition control in cars started a move from mechanical systems (carburetors and points) to electronic systems (EFI and electronically controlled ignition). These electronic systems rely on sensors to measure various parameters, such an engine airflow, engine speed and throttle position, with an Electronic Control Unit (ECU) then making decisions about the fuel injection pulse width and ignition timing. Most of these systems have the ability to detect and store faults in memory so that they can be later read out and diagnosed.

It comes as no surprise then that the airbag control system not only has the ability to store data but also uses a wide variety of sensors as part of its decision making process. However, the use of the controller as an Event Data Recorder (EDR) goes a step further – not only are fault codes stored but in some systems, the outputs from a variety of sensors are also continually logged.

Early development

So how did this come about? The story goes back to the early 1970s, when the US National Transportation Safety Board recommended that vehicle manufacturers gather information on vehicle crashes using on-board collision sensing and recording devices. As a result, since 1974, General Motors (GM) systems have recorded data for impacts that resulted in the triggering of the airbag (a "deployment event"), while other systems were also introduced that could additionally record "near deployment" events.

Subsequently, in 1999, GM introduced a system that could also record pre-crash data – ie, data is recorded to a buffer on a continuous basis and overwriting ceases immediately if a crash occurs. Ford in the US started installing EDRs in one model in 1997 and by 1999 nearly all its US models were so equipped. A range of other manufacturers either admit to some data recording or are looking to implement such strategies.



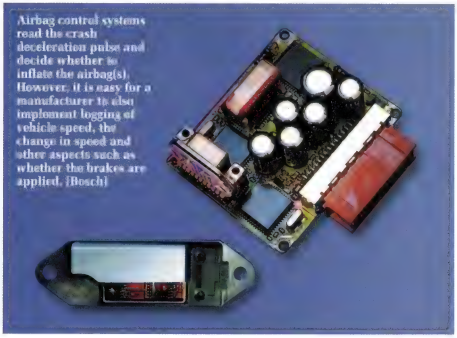
Airbags have saved many lives since they were first introduced. (DaimlerChrysler)

Rather than use airbag control systems to record crash and pre-crash data, some US-manufactured heavy trucks use the engine's ECU instead. For example, Cummins, Detroit Diesel and Caterpillar all use electronic control systems on their diesel engines which also log driving data.

The GM airbag system

The information recorded by GM airbag systems includes data for both deployment and near deployment events.

A near deployment event (ie, one where the airbag doesn't inflate) is defined as an event that's severe enough to "wake up" the algorithm within the control unit (an algorithm


Airbag control systems read the crash deceleration pulse and decide whether to inflate the airbag(s). However, it is easy for a manufacturer to also implement logging of vehicle speed, the change in speed and other aspects such as whether the brakes are applied. (Bosch)

This GM airbag controller contains a full Event Data Recorder. The data logged just before and during the crash can be read either directly from the module or if the wiring is intact, from the car's diagnostic port. [Vetronix]

is used to analyse the severity of the crash pulse; ie, the control unit uses the shape and magnitude of the deceleration pulse it is undergoing before deciding whether or not to fire the airbag).

Two different systems are used by GM; one stores data on the near deployment event which had the greatest change in road speed, while the other stores the most recent near deployment event. In both cases, the following data is recorded:

- Driver's Seat Belt: this is recorded as buckled or unbuckled. However, this may be recorded incorrectly if power to the unit is lost during the crash.
- SIR Warning Lamp: the on/off status of the Supplemental Inflatable Restraint warning lamp is recorded.
- Change in Forward Velocity: this is determined by integrating the average of four 312µs acceleration samples and is recorded in RAM every 10ms. Depending on the module, either 300ms or 150ms of this data is available.
- Time To Deployment: the time in milliseconds between the start of the event (ie, enabling of the algorithm which requires two consecutive acceleration samples of over 2g) and the command for the airbag deployment.
- Time Between Events – the time in seconds between a deployment event and a near deployment event, if that time is less than five seconds.
- Vehicle Speed: the pre-crash speed, recorded every second for five seconds prior to any event. This information is derived from the vehicle speed sensor.
- Engine RPM: engine speed, as derived from the engine management system. As with vehicle speed, it is recorded every second for five seconds prior to any event.
- Throttle Opening: the percentage that the throttle is open, where 100% is wide open. This information is sent by the engine management system along with engine and vehicle speeds and is again recorded every second for 5s prior to any event.
- Brake Status: brakes on/off, as derived from the ABS or engine management unit every second for 5s prior to any event. Braking intensity is not recorded.
- Data Validity: a check that none of the four pre-crash parameters (vehicle speed, engine rpm, throttle opening or brake status) is out of range or has logged faults.

In addition, the number of ignition key cycles at the time of the events and at the time of download is logged, as is whether or not the passenger-side front airbag has been manually switched off.

One of the two GM EDR units is designed so that 150ms after the deployment algorithm has been enabled, all the data stored in the memory is permanently written to EEPROM. It then cannot be erased, cleared or altered, so this type of device must be replaced after an airbag deployment.

As a matter of interest, the Ford system records both longitudinal and lateral acceleration, the deployment strategy for the dual-stage airbag, seat-

The BMW airbag module. The extent to which various manufacturers are logging real-time data is largely unknown but it's possible that this unit already has this capability built in. [BMW]

The same control module that's used to deploy the airbags can also be used to log vehicle data before, after and during a crash. Such systems could be in widespread use in just a few years. [DaimlerChrysler]

belt use, pretensioner operation and the fore-aft position of the driver's seat.

One reason that data from the GM system is being widely used in crash research is that the company licensed the Vetronix Corporation to build a data retrieval tool for their EDR as far back as 1999. Ford subsequently followed suit for their own EDR system.

The Vetronix Crash Data Retrieval (CDR) tool consists of both hardware and software. The hardware component comprises an interface between the vehicle's diagnostic connector (or the EDR itself where the vehicle wiring has been damaged) and a PC. In operation, the CDR system reads the hexadecimal code stored in the EDR and converts it to engineering units, making it available in both tabular and graphical forms.

And the cost of this unit? – about $US2500.

Data usefulness

EDRs improve crash analyses, both by simplifying and improving the accuracy of the reconstruction process. This results in more detailed and more accurate conclusions. Tables 1 & 2 summarise the information available to crash investigators with and without EDRs.

Before EDR, crash investigators could only rely on vehicle damage and other obvious physical signs like skid marks (less likely with ABS) in order to make major judgements. So logged data on vehicle speed and other parameters can be very useful.

Data validity

So how good is the data collected via an EDR? The answers to that question are surprisingly broad; certainly there is plenty of information available for someone who wants to fight EDR evidence in a court of law. However, on the other side of the fence, if used carefully, the data gained from an EDR is invaluable when it comes to determining the events that occurred before and during the crash.

So just what are the potential problems? They are as follows:

- Problem 1: vehicle speed, engine rpm, throttle opening and brake status are logged only once per second – a sampling frequency that's much too low when analysing many types of crashes. For example, did the driver brake at 3.1 or 3.9 seconds before impact? The difference is major. Additionally, this data is not synchronised with the start of the crash data and is potentially offset from the crash data by up to one second.
- Problem 2: the recorded data goes back only five seconds before the algorithm enable event occurs. There is no record of vehicle behaviour earlier than this – behaviour which might show erratic driver inputs, for example.
- Problem 3: the use of only five data points for each of the speed, rpm, throttle opening and brake status parameters can give a false impression; eg, if the data is plotted on a graph, with the various points connected by a straight line. In reality, the true values of any of these parameters might have been quite different between the discrete points, compared to the values indicated by the graphs.
- Problem 4: most EDRs record speed

Table 1: Information Available Without EDR

	Human	Vehicle	Environment
Pre-Crash		Skid marks	
Crash		Calculate change in velocity	
Post-Crash		Crash damage	Environment after crash

Table 2: Information Available With EDR

	Human	Vehicle	Environment
Pre-Crash	Seatbelt use; Throttle input; Braking	Road speed; Engine speed	Conditions during crash
Crash	Airbag data; Seatbelt pretensioners	Crash pulse; Measured change in velocity; Airbag inflation time	Location
Post-Crash	Automatic crash notification*	Automatic crash notification*	Automatic crash notification*

*Automatic crash notification refers to systems which can automatically alert authorities (eg, by mobile phone) when an accident occurs and give the location.

Potential Benefits of Event Data Recorders

(1). Real Time Assistance: the use of EDR data in conjunction with Automatic Collision Notification systems would aid in quickly locating crashes and despatching emergency personnel with better crash information in advance.

(2). Law Enforcement: obtaining impartial EDR data from a collision would help in more accurately determining the facts surrounding the incident.

(3). Government Initiatives: the collection of EDR data would enable governments to introduce effective initiatives to help reduce fatalities, injuries and property loss.

(4). Vehicle Design: EDRs allow manufacturers to collect accurate data to monitor system performance and improve vehicle design.

(5). Highway Design: the use of EDR data can assist in assessing highway roadside safety and managing road systems.

(6). Insurance/Legal: Additional objective data provided by EDRs advance quicker and fairer resolution of insurance and liability issues

(7). Research: EDR data could provide objective data for researching driver behaviour and performance, as well as other research related topics.

(8) Owners/Drivers: EDRs can help fleet owners and drivers monitor vehicle and driver performance, to ensure the safe and efficient movement of people and cargo.

Canadian Multidisciplinary Road Safety Conference, 2001.

Pre-Crash Graph GM Airbag Module

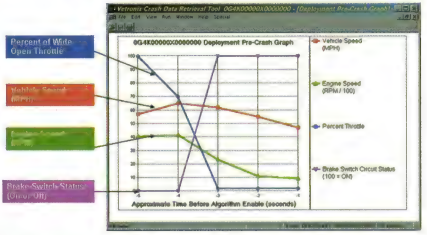


Fig.1: this is a sample of the pre-crash data that is logged by the GM system, as read out using the Vetronix Crash Data Retrieval tool. Throttle opening, engine and road speed, and the on/off status of the brake switch are logged at 1-second intervals for the five seconds before the crash. [Vetronix]

Post-Crash Graph GM Airbag Module

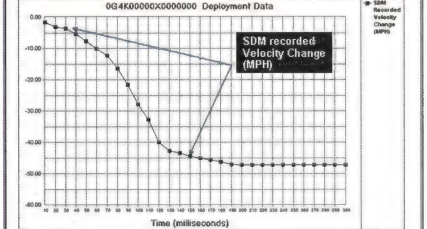


Fig.2: during the crash, the change in speed is logged every 10ms, to allow a detailed examination of the impact behaviour. The airbag system's accelerometer is used in this process. [Vetronix]

only in a longitudinal direction. However, many accidents also involve lateral as well longitudinal movement and so the speed recording may give a false impression of the events that occurred. No current original equipment EDRs record vertical accelerations.

- Problem 5: where the crash does not involve a major deceleration – eg, when a large truck hits a small car or when a pedestrian is run over – the EDR may not record the event at all.
- Problem 6: vehicle speed, engine rpm, throttle opening and brake status all depend for their accuracy on sensors and/or switches. However, vehicle speed and throttle position sensors can vary by up to 10% in accuracy, a point that seems to have been overlooked by some researchers.

This dedicated reader is designed to work with GM and Ford EDR systems. It costs US$2500, putting it within easy reach of professional crash investigators and researchers. [Vetronix]

Other research

A great deal of work has gone into testing the relationship between the data gathered from EDRs and that gained through other logging techniques. One approach is to measure the vehicle's change of velocity using the EDR and compare that figure with the crash test impact speed.

A series of Canadian tests has shown that there is usually fairly good agreement between the calculated and actual speeds – eg, an actual impact speed of 40.3km/h and an EDR-calculated speed of 42.4km/h. Typically, the EDR showed a slightly higher speed because it was affected by the car bouncing back off the barrier after the collision.

However, one test involving a 2000 Ford Taurus had a significantly greater difference between the actual (47.8km/h) and EDR (53.6km/h) speeds. The testers suggested that this discrepancy had been caused by a spike in the acceleration/time curve, caused by structural deformation in the area where the EDR was mounted. A major discrepancy also occurred in another test, where a 1988 Chevrolet Cavalier's EDR lost power during the crash. The independently measured test speed was 64.8km/h but the EDR showed 56.8km/h.

Away from the laboratory, the usefulness of the data – even with these reported inaccuracies – can be clearly demonstrated. In one case, an 83-year-old male driver of a 2000 Buick Cen-

Analysing An Accident

Table 3: System Status At Deployment	
SIR Warning Lamp Status	Off
Driver's Belt Switch Circuit Status	Unbuckled
Passenger Front Air Bag Suppression Switch Circuit Status	Air Bag Not Suppressed
Ignition Cycles At Deployment	187
Ignition Cycles At Investigation	213
Time From Algorithm Enable To Deployment Command Criteria Met (ms)	18.75
Time From Algorithm Enable To Pretensioner Deployment Command Criteria Met (milliseconds)	18.75
Time Between Near Deployment and Deployment Events (seconds)	N/A

Time (milliseconds)	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Recorded Velocity Change (MPH)	-1.54	-3.07	-3.51	-5.27	-7.68	-10.09	-12.29	-16.24	-21.50	-27.86	-32.69	-39.93	-42.78	-43.44	-44.32

Time (milliseconds)	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
Recorded Velocity Change (MPH)	-44.98	-45.42	-46.07	-46.95	-47.17	-47.17	-47.17	-47.17	-47.17	-47.17	-47.17	-47.17	-47.17	-47.17	-47.17

Pre-Crash Data + Electronic Data Validity Check Status = Valid

Time Before Algorithm Enable	Vehicle Speed (MPH)	Engine Speed (RPM)	Throttle Position (%)	Brake Switch Status
-5s	57	4032	100	Off
-4s	65	4160	70	Off
-3s	62	2304	2	On
-2s	55	1088	2	On
-1s	47	896	2	On

Table 3: this is a summary of the data that can be gained from GM's EDR. Note that the driver's seatbelt was undone and that the vehicle was travelling at 47mph (76km/h) at impact. This can be seen both in the vehicle speed and also the Recorded Velocity Change figures. [Vetronix]

tury was negotiating a right-hand curve when he ran off the road, travelled down an embankment into brush and tall grass, then crossed a level section of lawn and a gravel driveway before finally colliding with two large rocks. The car came to rest approximately 140 metres from where it left the road.

Pre-crash data obtained from the EDR indicated that the driver wasn't operating the throttle or the brakes for at least five seconds prior to the impact with the rocks. At the crash scene, the driver was lethargic and he subsequently died in hospital. An autopsy showed that he had died from the results of a brain haemorrhage that had occurred while he was driving – a diagnosis well supported by the EDR data.

Conclusion

If the US success at implementing onboard diagnostics in cars is repeated with EDR, it's very likely that all new cars will have accident crash logging in 5-10 years.

So if you are ever involved in a car crash and there's some debate about the circumstances, think about the implications of an EDR. It may only be a matter of time before authorities can access such data. **SC**

Who Owns The Logged Data?

While the potential benefits of EDRs are highlighted by road safety researchers, many drivers and some vehicle manufacturers are concerned about the privacy implications. In fact, the US Federal Motor Carrier Safety Administration has stated that the following standards should apply to controlling access to EDR data:

- The vehicle's owner should also own the EDR data.
- Only the vehicle's owner, or another party having the owner's permission, may access the EDR data. Exceptions would include instances where a law enforcement official has a warrant for a crash investigation.
- One method of assuring that only owners have access is through the use of an EDR password.
- The storage and retrieval of EDR data must protect the privacy rights of the individual in accordance with law.

At this stage, none of those points has been implemented, although truck owners can deactivate the EDR by setting the deceleration threshold inappropriately, giving them some measure of control over the data being collected.

Certainly, there needs to be more public debate about the privacy issues involved with EDR.

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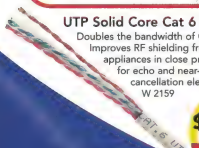

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DICK SMITH ELECTRONICS

A 12AX7 valve audio preamplifier

After many years saying we would never publish a valve circuit, here is a valve preamplifier for guitars and other musical instruments. However, it is a valve circuit with a number of differences, to give it much better performance than was common in the "olden days".

WHAT'S THIS? An audio project using a valve, actually described in SILICON CHIP? After all those scathing things our esteemed Editor and Publisher has said in the past about olde-worlde "bottles"? Yes, Leo finally gave in and approved the development of a valve preamp for guitars and other instruments, using the trusty 12AX7 dual hi-gain triode. We had to brush up on valve design to do it but the performance has turned out to be

quite impressive, better in fact, than was commonly achieved when valves ruled the electronics world.

Now you can build one up, so you can hear for yourself just how good "valve sound" compares with that from modern solid state gear.

How it developed

Once we had decided to do a valve preamp, the first step was to see what parts were still readily available. This narrowed down the choice straight away, since the only type of low power amplifier valve that is widely available is the trusty 12AX7. Older readers may remember that this is a dual high-mu indirectly heated triode, which was also known by the European type number ECC83 and the military number 7025.

It comes in a Noval or "miniature 9-pin" all glass envelope, and has a centre-tapped heater designed to operate from either 12.6V (at 150mA) or 6.3V (at 300mA). The 12AX7 is apparently still being made in Russia and a few other countries and Jaycar Electronics stocks the 12AX7WA made by Sovtek. They're brand new and they sell for $24.95 a pop (Cat. ZA-6000). Jaycar also stocks matching Noval sockets, as the PS-2082 ($4.40 each).

Of course, the valve is only part of the story, because valves not only need heater power to "light them up" and make the cathode emit electrons – they also need to operate from a fairly high voltage to attract those electrons to the anode or "plate".

In fact, for reasonable audio performance, a valve like the 12AX7 really needs to be operated from a "high tension" (HT) plate voltage supply of 250V DC or so. They don't draw much current from this high voltage supply (only a few milliamps) but the high voltage is necessary because valves are much higher impedance devices than transistors.

In the old days we'd usually generate this HT voltage with a simple rectifier circuit, based on a mains transformer with a high voltage secondary. But this sort of transformer is no longer readily available.

So the next step in developing our preamp was to come up with a suitable HT power supply, using more reasonably priced parts. Modern technology came to the rescue here, because nowadays it's easy to generate a high DC voltage with a low power DC-DC converter. This type of converter is quite efficient and low in cost thanks to the availability of converter chips like the TL494, fast switching rectifier diodes and high voltage power Mosfets such as the MTP6N60E.

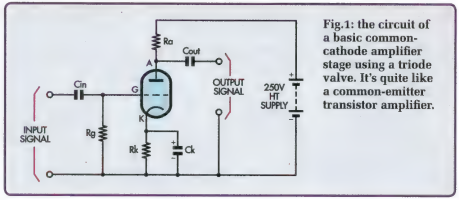


Fig.1: the circuit of a basic common-cathode amplifier stage using a triode valve. It's quite like a common-emitter transistor amplifier.

So as part of the preamp design, we had to come up with a suitable 12V/250V step-up converter to run it. More about this later, but now let's explain a bit more about designing the preamp itself.

One way in which valves are different from solid state devices is that they have much tighter parameter spreads. So the performance of one 12AX7 is almost exactly the same as any other 12AX7; unlike transistors and FETs, where things like the current gain and quiescent current tend to vary over a wide range.

Because of this much more predictable performance, valve amplifier stages are designed in a rather different way. In fact, many valve amplifier stages can be designed using a fairly straightforward graphical method, as we'll now explain.

Fig.1 shows the circuit of a basic common-cathode amplifier stage using a triode valve, such as one section of a 12AX7. As you can see, it's quite like a common-emitter transistor amplifier or a common-source FET amplifier. In fact, if you to think of the valve as a kind of "depletion mode FET" that operates from high voltage, you'll soon get the hang of things.

The anode (A) or plate of the valve is connected to the +250V HT supply via a load resistor Ra, which is rather like the drain resistor of a FET. And the current the plate draws is controlled largely by the voltage applied between the grid (G) and cathode (K), because the grid works very much like the gate of a depletion mode FET.

When there's virtually no voltage

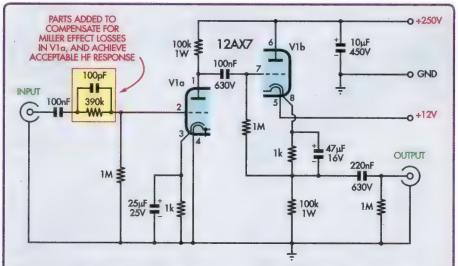


Fig.2: our first attempt at the valve preamplifier. The first circuit stage is a common-cathode amplifier while the second is a "cathode follower" to give low output impedance and avoid the severe performance losses which can occur when driving following stages. The input RC network compensates for Miller Effect high frequency loss.

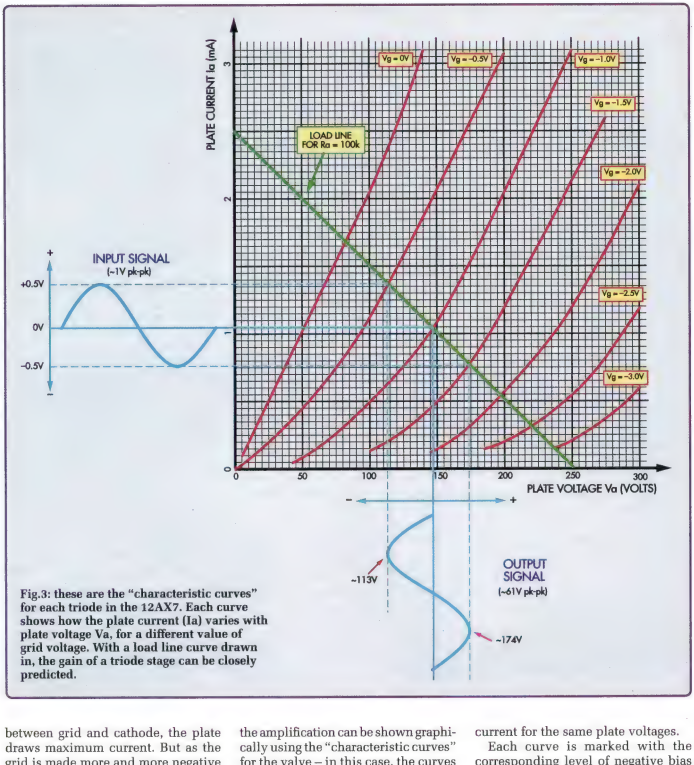


Fig.3: these are the "characteristic curves" for each triode in the 12AX7. Each curve shows how the plate current (Ia) varies with plate voltage Va, for a different value of grid voltage. With a load line curve drawn in, the gain of a triode stage can be closely predicted.

between grid and cathode, the plate draws maximum current. But as the grid is made more and more negative with respect to the cathode, the anode current is "throttled back". In fact, only a few volts of "negative bias" between grid and cathode are needed to make the plate current fall away and "cut off" the valve's conduction. It's this ability for a small voltage change on the grid (relative to the cathode) to control the valve's plate current that makes it a good amplifier.

If you look at Fig.3, you'll see how the amplification can be shown graphically using the "characteristic curves" for the valve – in this case, the curves for each triode in the 12AX7. As you can see, there are a number of curves, each one showing the way the valve's plate current (Ia) varies with plate voltage Va, for a different value of grid-cathode bias voltage Vg.

The steepest curve shows how quickly the current increases when there's no grid bias (Vg = 0). Then the other curves show how increasing levels of negative bias reduce the plate current for the same plate voltages.

Each curve is marked with the corresponding level of negative bias voltage: -0.5V, -1.0V, -1.5V and so on. Notice how with -3.0V applied to the grid, the valve only draws about 0.6mA of plate current even with a plate voltage of 300V.

Note that these curves only show the behaviour of the valve if it is connected directly to an adjustable DC voltage supply. But this isn't the situation in our amplifier stage of Fig.1, because here the valve is connected in series

with a fixed "plate load" resistor Ra, across a fixed 250V DC voltage supply. So in this case the voltage drops of the valve and load resistor Ra always add up to 250V. In effect, they share the voltage according to the ratio of their resistances.

For example, when the valve has a small negative bias voltage on the grid (so it's able to draw more current), its effective plate-cathode resistance is smaller than Ra and as a result Ra drops more of the voltage. Conversely, when the valve has more negative grid bias and can only draw a small current, its plate-cathode resistance rises compared with Ra and it now drops more of the voltage.

Because the voltage drops of Ra and the valve must always add up to the HT voltage (here +250V), this also means that the voltage across the valve can always be found by subtracting the voltage drop across Ra from the HT voltage. And since Ra is a fixed resistor, it's easy to find its voltage drop by Ohm's law: the voltage drop is simply Ra times the current.

We can show this graphically by drawing a "load line" to represent the behaviour of Ra on the valve's characteristic curves. As you can see from Fig.3, the load line is simply a straight line (shown in green) drawn between two known points. One is the point on the horizontal (voltage) axis representing the full HT voltage, because this will be the voltage on the valve's plate when no current is being drawn (so there will be no voltage drop across Ra).

The other known point is on the vertical (current) axis, showing the current which would be drawn by Ra by itself from the HT supply, if the valve could be fully "turned on" so that it had no voltage drop at all.

The load line shown is for a load resistor Ra of 100kΩ, so it's therefore drawn between the +250V point on the horizontal axis, and the point on the vertical axis corresponding to a current of 250V/100kΩ, or 2.5mA.

Now what this load line shows is the way the voltage on the plate of the valve must vary for different current levels, operating from a 250V plate supply and with an Ra of 100kΩ. And since the valve's own curves (red) show how its current varies with grid-cathode voltage Vg, we can use the two together to see how variations in Vg caused by an AC input signal will result in plate current variations and then much larger variations in the plate voltage.

In short, the valve will amplify the input signal.

After looking at the 12AX7's curves and the 100kΩ load line together, we can pick a suitable operating point for the two when they're operating from an HT of 250V. Since the load line intersects the Vg = -1.0V curve at about halfway along, this would make a fairly good operating point for a stage handling fairly small input signals (say ±0.5V or less). As you can see, at this point the valve would have a Va of about 146V, while Ra drops the remaining 104V (250 - 146V). The resting or "quiescent" plate current flowing through both will be about 1.05mA.

Cathode bias

By the way, once we decide to make this the valve's operating point, we can also choose the value of the self-bias cathode resistor (Rk in Fig.1). This will simply need a value which gives a voltage drop of 1.0V (the desired Vg), at the desired plate current (1.05mA). So Rk will have a calculated value of 952Ω, meaning that we can use the nearest preferred value: 1kΩ.

It's now fairly easy to show the valve's amplification at this operat-

Parts List

Preamp PC Board

1 PC board, code 01111031, 125 x 62mm
1 UB3 jiffy box, 130 x 67 x 44mm
1 piece of 1mm aluminium sheet, 125 x 62mm
1 12AX7WA or ECC83 twin triode valve
1 Noval 9-pin valve socket
2 PC-mount RCA sockets
2 2-way PC terminal blocks
6 6mm untapped metal spacers
4 M3 x 12mm machine screws
8 M3 nuts and star lockwashers

Capacitors

1 220µF 10/16V PC electrolytic
1 47µF 450V PC electrolytic
1 220nF (0.22µF) 630V metallised polyester (greencap)
1 100nF (0.1µF) 100V metallised polyester (greencap)
1 100nF (0.1µF) 630V greencap

Resistors (0.25W 1% metal film)

3 1MΩ
2 33kΩ
2 100kΩ 1W carbon film
1 8.2kΩ
2 1kΩ

Power Supply

1 PC board, code 01111032, 122 x 58mm
2 TO-220 mini heatsinks (6073B type)
2 2-way miniature PC-mount terminal blocks
1 1m-length .08mm enamelled copper wire
1 3m-length 0.25mm enamelled copper wire
1 Ferroxcube ETD29-3C90 ferrite transformer assembly (2 ETD29-3C90 cores; 1 CPH-ETD29-1S-13P bobbin and 2 CLI-ETD29 clips); OR
1 Neosid ETD29-F44 ferrite transformer assembly (2 ETD29 F44 32-580-44 cores; 1 ETD29 59-580-76 bobbin and 2 ETD29 76-055-95 clips)
1 2.5mm PC-mount DC socket
4 6mm untapped metal spacers
2 M3 x 10mm machine screws
4 M3 x 15mm machine screws
6 M3 nuts and lockwashers

Semiconductors

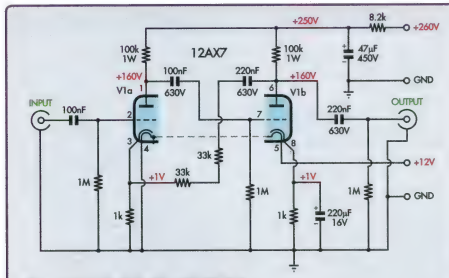
1 TL494 switchmode controller (IC1)
1 7812 3-terminal regulator (REG1)
1 BC337 NPN transistor (Q1)
1 BC327 PNP transistor (Q2)
1 MTP6N60E 600V/6A or STP-6N50B 500V/5.8A Mosfet (Q3)
1 1N4004 1A power diode (D1)
1 UF4004 400V fast switching diode (D2)

Capacitors

1 2200µF 16V PC electrolytic
1 470µF 25V PC electrolytic
1 10µF 450V PC electrolytic
1 10µF 35V TAG tantalum
1 1nF (.001µF) MKT metallised polyester

Resistors (0.25W 1%)

3 680kΩ 1W
1 220kΩ
1 47kΩ
1 100kΩ horizontal trimpot (VR1)
1 39kΩ
1 4.7kΩ
1 1kΩ



SC 2000 12AX7 VALVE PREAMP

Fig.4: the final preamp circuit uses two triode common-cathode stages with negative feedback from pin 6 to pin 4, to greatly improve distortion and frequency response. Note the HT filtering network which reduces noise and hash on the 260V supply.

ing point, as you can see in Fig.3. If we draw a horizontal line off to the left from the operating point, this becomes the zero axis for our audio input signals fed to the valve's grid via capacitor C_{in}. Similarly by drawing a vertical line down from the operating point, this becomes the zero axis for the amplified audio signals that will appear at the valve's plate and are coupled out via capacitor C_{out}.

So when we draw a sample sine-wave input signal of say 1.0V peak-to-peak (±0.5V) as shown, we can run horizontal lines through from the signal's peaks to the points where they intersect the load line. Then we can draw vertical lines down from those points, because these must represent the plate voltage and current levels which will correspond to those signal peaks. Then we can reconstruct the valve's output signal as shown, underneath the curves.

Notice that the output from such a 1.0V peak-to-peak input signal will have a peak-to-peak amplitude of about 61V (174V - 113V), showing that the valve should provide an amplification or "gain" of about 61 times. As you can see the output waveform is also `upside down' with respect to the input waveform (positive input peak becomes negative output peak), showing the way the valve inverts the signal polarity – just like a transistor or FET.

So that's the basic way a triode valve amplifier stage is designed, using the graphical method. Practical design is a little more involved than that though, because there are a few complications. For example, the gain will never be quite as high as we find from the curves, because whatever AC load we connect to the output capacitor C_{out} is effectively in parallel with Ra (as far as the AC signals are concerned), which reduces its effective value – and hence the gain we can achieve.

Miller Effect high frequency loss

There's also another complication when the stage is amplifying higher audio frequencies, caused by the valve's internal capacitance between its grid and plate. In each section of the 12AX7, the internal grid-plate capacitance is about 1.7pF, which rises to about 2pF when the valve is plugged into a socket.

Now this capacitance is connected directly between the amplifier's input and output, and because the two are opposite in phase due to the signal's inversion, the capacitance provides a path for negative feedback. In addition, the capacitance tends to pass much more reactive current than it would as a result of the input signal alone. In fact, it draws (A+1) times the current, where A is the stage gain.

So this internal capacitance acts as if it was a capacitor A+1 times larger than its real value, a phenomenon known as the "Miller Effect". As a result, this kind of triode amplifier stage tends to have a fairly poor high-frequency response. For example, due to the Miller Effect our 12AX7's 2pF of grid-plate capacitance will have an effective value of about 124pF in the circuit of Fig.1, which has a drastic effect on its frequency response.

First prototype circuit

But enough of theory. Our first attempt at a preamp circuit using the 12AX7 used the circuit shown in Fig.2. As you can see it consists of a voltage amplifier stage just like that in Fig.1, with a 100kΩ plate load resistor, a 1kΩ self-bias resistor and a 1MΩ grid resistor.

To try and achieve as high a gain as possible, even when the output of the preamp was connected to a main amplifier or mixing desk with a fairly low input impedance, we used the second triode section of the 12AX7 as a "cathode follower" with its 100kΩ load resistor connected from the cathode to ground rather than from the plate to +250V.

This makes the second stage have a gain of slightly less than unity, but at the same time it provides a high AC load impedance for the first stage plus a low source impedance to drive the following amplifier. This means that capacitance effects of the output signal cable will not cause further reductions in the high-frequency response.

This arrangement gave an overall gain of about 36 times but the high-frequency response was quite poor, due to Miller Effect in the first stage. The upper -3dB point was only 5kHz but we were able to compensate for

Performance

Voltage Gain: 61

Frequency response: -1dB at 20Hz and 160kHz (see Fig.5)

Harmonic distortion: <0.2% for output levels up to 3V RMS (see Figs.6 & 7)

Signal-to-noise ratio: -81dB unweighted (22Hz to 22kHz) with respect to 2V

Input impedance: 1MΩ

Output impedance: 1.5kΩ at 1kHz

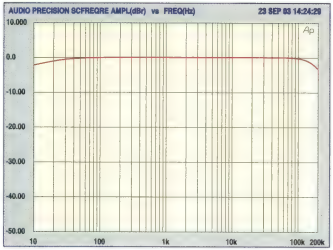


Fig.5: the frequency response is very smooth, with -1dB points at 20Hz and 160kHz, measured at 2V into a 50kΩ load. Because the output impedance is low, the frequency response will not be curtailed by an amplifier load.

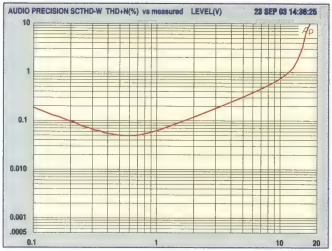


Fig.6: total harmonic distortion at 1kHz, measured into a 50kΩ load and with a measurement bandwidth of 22Hz to 22kHz. Note that most valve circuits do not have negative feedback and so their distortion is considerably worse.

that loss by adding an input compensation circuit (shown highlighted in Fig.2). However, this dropped the gain to 34 times, which we judged to be inadequate.

The distortion level we achieved with this configuration was also fairly high – about 0.9% with an output level of 3V RMS, and rising to above 5% for an output level of 16V RMS. These are very high levels of distortion compared to good solid-state designs but this was typical of valve stages operating without any negative feedback – which was the usual approach.

At SILICON CHIP we have always tried to produce the best available audio performance, so we decided to try a different approach, converting the second preamp stage into a common-cathode amplifier like the first, and then applying a fair amount of negative feedback around the two.

The goal was higher overall gain, combined with a much more extended frequency response and much lower harmonic distortion. The negative feedback would also reduce the output impedance of the second stage, to make it easily drive following stages without high frequency loss.

To cut a long story short, this new configuration worked much better and as noted at the start of this article, the overall performance is far superior to that normally achieved by valve audio circuits from the "olden days".

Circuit description

Fig.4 shows the final circuit configuration. The input signal is coupled into the grid of triode V1a via a 100nF capacitor, with a 1MΩ resistor to tie the grid at DC earth potential.

The idea of using a 1MΩ grid resistor is to achieve the best possible low-frequency input response with the 100nF coupling capacitor (1MΩ is the highest allowed value for the 12AX7's grid resistor).

V1a has a 100kΩ plate resistor, as before, and the cathode bias resistor is also 1kΩ. But the latter isn't bypassed with a capacitor, because we use it as part of the negative feedback divider. The output from the plate of V1a is coupled to the grid of V1b, the second triode section of the 12AX7, via a second 100nF capacitor. This capacitor is rated at 630V because it has to be able to withstand the full HT voltage.

The second stage is almost identical to the first except that its 1kΩ cathode resistor is now bypassed with a 220μF capacitor, to achieve the maximum possible gain. The preamp's output is taken from the plate of V1b via a 220nF coupling capacitor, which again must be rated to withstand the full HT voltage. The final 1MΩ resistor to ground is to allow the 220nF capacitor to charge up as soon as the HT voltage is applied, rather than running the risk of it only charging later on when we connect the preamp to a load (which would cause a loud "plop" sound).

A second 220nF capacitor is connected to the plate of V1b, to couple the negative feedback signal back to the cathode of V1a via the two 33kΩ series resistors. (We use two resistors in series because of the fairly high voltage swings.)

The negative feedback divider formed by the two 33kΩ resistors and the 1kΩ cathode resistor has a division factor of 1/(66+1) or 1/67. This gives

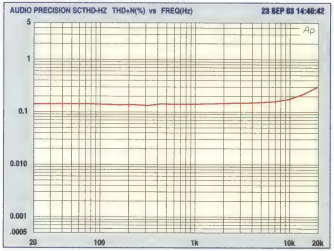


Fig.7: total harmonic distortion versus frequency, measured at 2V into a 50kΩ load and with a measurement bandwidth of 22Hz to 80kHz. Even the very best valve amplifier circuits (with negative feedback) of the past would have been struggling to match this performance.

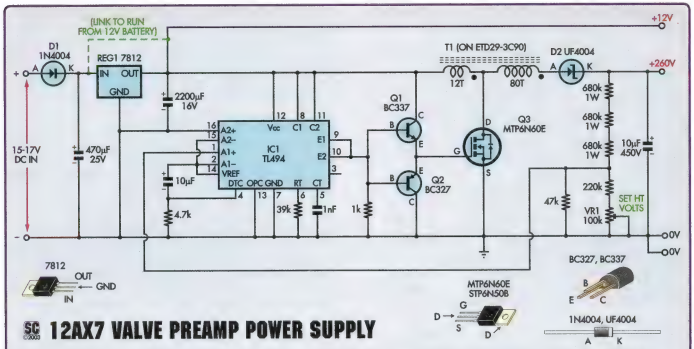


Fig.8: the DC-DC converter uses a TL494 switchmode controller to drive Mosfet Q3 in a boost converter running at around 33kHz. T1 is wired as an auto-transformer to step-up the voltage developed in the 12-turn primary winding.

the preamp a theoretical final gain of very close to 67. In practice, the measured gain was 61.

The performance of this final preamp configuration is shown in the plots, produced on SILICON CHIP's Audio Technology test system. Fig.5 shows the very smooth frequency response, with -1dB points at 20Hz and 160kHz, measured at 2V into a 50kΩ load.

Figs.6 & 7 shows the harmonic distortion performance. Total harmonic distortion (THD) is below 0.2% for output levels up to about 3V RMS (8.5V peak-to-peak). The distortion remains below 1% at output levels up to about 12V RMS and then goes into soft clipping at higher levels.

The distortion is mainly second harmonic, as expected.

The preamp's signal-to-noise ratio is better than -81dB unweighted (22Hz to 22kHz measurement bandwidth) with respect to 2V RMS output. Most of the noise is a low-level "frizzle" from the 33kHz switching hash of the DC-DC converter.

The preamp's input impedance is very close to 1MΩ while its output impedance measures very close to 1.5kΩ, thanks to the negative feedback.

Before leaving the preamp circuit, note that the HT supply is fed to the circuit via an 8.2kΩ resistor which is then bypassed by a 47µF 450V electrolytic capacitor. This RC network provides a high degree of noise filtering and removes most of the residual high frequency noise and hash superimposed on the HT line from the DC-DC converter. The voltage on the decoupled line is +250V which means that the DC-DC converter needs to deliver about +260V.

DC-DC converter

Now let's look at the DC-DC converter circuit shown in Fig.8. As we

Table 2: Capacitor Codes

Value	µF Code	EIA Code	IEC Code
220nF	0.22µF	224	220n
100nF	0.1µF	104	100n
1nF	.001µF	102	1n

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	3	1MΩ	brown black green brown	brown black black yellow brown
❑	3	680kΩ	blue grey yellow brown	blue grey black orange brown
❑	1	220kΩ	red red yellow brown	red red black orange brown
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	1	39kΩ	orange white orange brown	orange white black red brown
❑	2	33kΩ	orange orange orange brown	orange orange black red brown
❑	1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	3	1kΩ	brown black red brown	brown black black brown brown

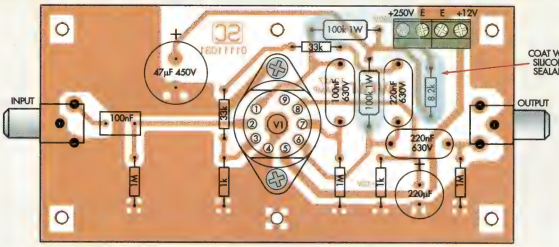


Fig.9: the parts layout for the preamp board. Make sure that the electrolytic capacitors are installed with the correct polarity and note that the high-voltage components must be covered with neutral-cure silicone sealant.

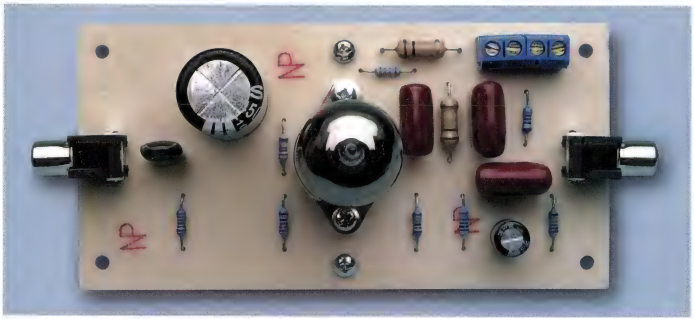
mentioned earlier, we have to provide the valve with an HT supply of about +260V in addition to the low voltage needed for its heaters. Current requirements from the HT supply are quite small – only about 2mA for both preamp stages. Since the 12AX7's heaters can also run from 12V DC, this has the advantage that the complete preamp can be run from either a 12V battery or a suitable 12V DC plugpack. The total drain from the 12V source is only about 250mA.

By the way, it's actually very desirable to run the 12AX7 heaters from 12V DC in an audio preamp, because this removes a major source of hum. When the valve heaters were run from 12.6VAC in the "valve days", it was very difficult to avoid a small amount of 50Hz hum caused by heater-cathode leakage and capacitance – plus some 100Hz hum caused by thermal modulation.

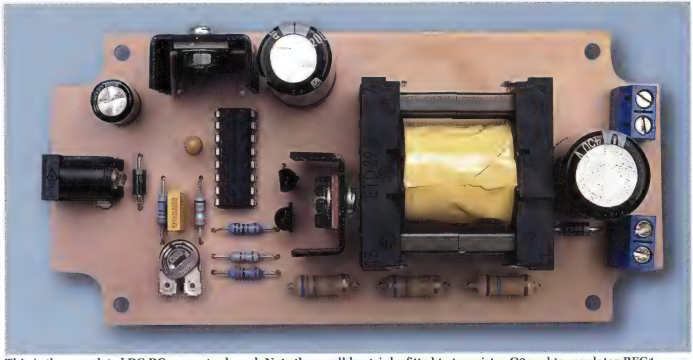
As you can see from the circuit of Fig.8, the power supply is quite straightforward. Regulator REG1 is included so that the preamp can be operated from an unregulated plug pack, while still providing both the valve heaters and the DC-DC converter with smoothly regulated 12V DC. If you want to run the preamp from a 12V battery, the regulator is simply omitted and replaced by a wire link.

The DC-DC converter uses a standard "flyback boost" circuit, where energy is first drawn from the +12V supply and stored in the 12-turn primary winding of transformer T1, by turning on Mosfet Q3 (which acts as a high-speed switch). Then Q3 is turned off, so that the stored energy is returned to the circuit as a high voltage "flyback" pulse, induced in both windings of T1.

Because the two windings are connected in series, this output pulse is



This view shows the fully assembled preamplifier board. When you finish testing the preamp, coat the 100kΩ resistors, the 8.2kΩ resistor the HT connection on the terminal block with neutral-cure silicone sealant – see Fig.9.



This is the completed DC-DC converter board. Note the small heatsinks fitted to transistor Q3 and to regulator REG1.

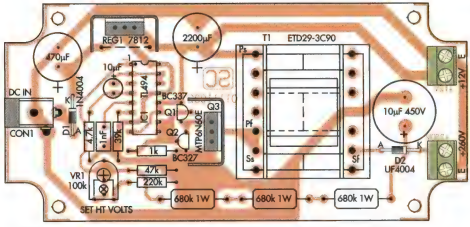


Fig.10 the component layout for the DC-DC converter board. Fit the flag heatsinks before installing REG1 and Mosfet Q3.

added to the +12V input, boosting it still further. Fast switching diode D1 then feeds the pulse energy into the 10µF capacitor, which charges up to about +260V.

The capacitor voltage becomes the preamp's HT supply and we maintain it at a little over 260V by feeding a known proportion back to IC1, a TL494 switching controller. This compares the feedback voltage with an internal reference voltage (5V) and automatically adjusts the width of the switching pulses fed to Q3 (via driver transistors Q1 and Q2). This controls the energy stored in T1 to produce each flyback pulse and hence makes sure the HT output voltage is not allowed to rise higher or fall lower than 260V.

The feedback voltage for IC1 is derived from the HT output via a resistive voltage divider, as you can see. The three 680kΩ 1W resistors in series form the upper arm of the divider, with a total value of 2.04MΩ (we use three 1W resistors to handle the voltage drop rather than the power dissipation, which is only 30 milliwatts!). The lower divider arm is formed by the 47kΩ resistor in parallel with the 220kΩ and 100kΩ trimpot (VR1) which allows the output voltage to be adjusted over a small range.

The TL494 has an internal oscillator to generate the switching pulses fed to Q3, and the oscillator's frequency is set by the values of the resistor and capacitor connected to pins 6 and 5. The values shown (39kΩ and 1nF) give the converter an operating frequency of 33kHz, which is high enough to ensure that any output ripple which finds its way into the preamp (either via the HT line or by radiation) will be inaudible.

Transistors Q1 and Q2 are used to buffer the PWM (pulse width modulated) pulses generated by IC1, providing a low impedance high current drive for the gate of Q3. This is to make sure that Q3 is switched on and (especially) off as rapidly as possible, which is necessary to achieve high converter efficiency and minimise Q3's power dissipation.

By the way, this DC-DC converter is capable of supplying up to about 40mA of current at 260V (dependent on plugpack rating), so it's certainly capable of feeding two preamps if you wish to have a stereo pair. It would also be suitable for running other valve circuits, such as a mantel radio. In that respect, it could substitute for the vibrator in some 12V sets, although we have not checked its performance in this application.

Construction

All of the components for the preamp itself are built on a small PC board which measures 125 x 62mm – just the right size to mount on the top

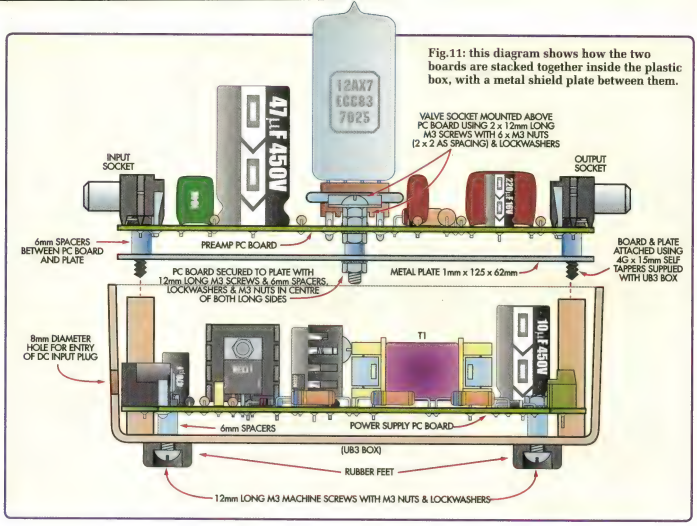


Fig.11: this diagram shows how the two boards are stacked together inside the plastic box, with a metal shield plate between them.

of a standard UB3 size jiffy box, as you can see from the photos. The power supply is built on a slightly smaller PC board measuring 122 x 58mm, which is designed to go down inside the UB3 box and out of sight. The two boards have the code numbers 01111031 and 01111032 respectively.

We designed the preamp and power supply on two separate boards to make it easier for people to build a "2 preamp + 1 power supply" combination, if they wish. It also gives you more options when it comes to physical construction, because you don't have to build them into a jiffy box. They could be built side-by-side in a metal box, if you'd prefer.

Having the power supply separate also makes it easier to use it to power other valve projects.

The construction details of both board assemblies should be fairly clear from the wiring diagrams and photos. Fig.9 shows the component layout for the preamp board while Fig.10 shows the layout for the DC-DC converter board.

Note that the valve socket for the 12AX7 is mounted above the centre of the preamp board, using two 12mm-long M3 machine screws through the flange holes and the matching board holes.

A pair of M3 nuts on each screw are used as spacers, with a lockwasher and nut on each screw under the board to hold everything together. Fig.11 shows how the two boards are stacked together, as well as the way the preamp board is mounted to the metal box lid and shield plate.

The audio input and output connectors are RCA sockets, mounted directly on the preamp board at each end. The power connections are brought out to board-mounting mini screw terminal blocks, which accept suitable insulated hookup wire. The power supply board has the same kind of screw terminal blocks.

All of the parts used in the power supply are also built directly onto the board, including converter transformer T1. This is wound on a Ferroxcube ETD-29 ferrite transformer assembly, which uses two E-cores made from 3C90 ferrite material plus a bobbin type CPH-ETC29-1S-13P, and two clips type CLI-ETD29.

The construction details for T1 are shown in Fig.12. The 12-turn primary winding is wound on the bobbin first, using 0.8mm diameter enamelled copper wire (ECW). This is then covered in a couple of layers of PVC insulation tape, over which is wound the secondary winding. The secondary is wound using 0.25mm ECW, as two layers of 40 turns each with a layer of insulation tape between the two layers.

Then when the end of the secondary is soldered to the appropriate former pin (5f), another few layers of PVC tape are applied over the top of the windings to protect them and hold everything in place.

The location and orientation of all parts on the power supply board should again be fairly clear from the wiring diagram of Fig.10 and the photos. Note that REG1 and Q3 are both mounted vertically on the board and each is fitted with a TO-220 mini

The DC-DC converter board is mounted in the bottom of the plastic case, while the valve preamp board is mounted on an aluminium shield plate. The DC supply leads from the converter are fed through a rubber grommet.

heatsink (19 x 19 x 10mm) like the Jaycar HH-8502. These ensure that they run within ratings. In practice, you will find that the Mosfet (Q3) runs cool, while the 3-terminal regulator gets quite warm or even, depending on the input voltage from your DC plugpack.

Take care when you're fitting all of the polarised parts to the board – especially the electrolytic capacitors, the diodes, the transistors and the IC and regulator.

The finished power supply board is mounted in the bottom of the UB3 box using four 15mm long M3 machine screws, with M3 nuts and star lockwashers. Four 6mm long untapped metal spacers are used to provide clearance for the solder joints under the board.

Three lengths of insulated hookup wire are used to connect the power supply outputs to the screw terminals on the preamp board. The preamp board itself is mounted above a 125 x 62mm piece of 1mm thick aluminium sheet, which is identical to the alternative metal lid sold with some UB3 boxes. The dimensions of the plate are shown in Fig.13.

The aluminium plate supports the preamp PC board as well as providing shielding between it and the power supply board. The preamp board is spaced above the plate using six 6mm-long untapped metal spacers.

It's attached to the plate initially using two 12mm long M3 machine screws with M3 nuts and star lockwashers, passing through the centre holes on each long side of the board. Then when the plate is placed in the top of the box, the four 4G x 15mm self-tappers supplied with the box are passed through the four corner holes (and the remaining four spacers), to hold the board and plate assembly together as well as firmly in the box.

Note that the three lengths of hookup wire used to connect the power supply to the preamp board are brought out through an 8mm hole in the metal plate, with a grommet to protect the insulation from chafing.

Checkout & adjustment

Before you fit the preamp board assembly into the top of the box, it's a good idea to check that everything is working and also to adjust the HT voltage output via trimpot VR1.

Do this by first plugging your 12AX7 valve into the preamp socket. Make sure you orientate the valve correctly, using the gap between pins 1 and 9 as a guide. Also push the pins into the socket clips gently, so they don't bend and possibly crack the glass envelope.

Now set trimpot VR1 to its mid position and then connect a DMM (set to a range such as 0-400V DC) across the HT terminals of either the power supply or preamp boards. After this, connect the power input of the power supply board to either a 12-15V DC plugpack (500mA or better) or a 12V battery, depending on the power source you're planning to use for the preamp.

A few seconds after you connect the power, you should see the heaters of the valve begin glowing as they heat up. At the same time the DMM reading should rise up to 260V or thereabouts, as the DC-DC converter output builds up. If the voltage rises higher than 260V or lower than 250V, adjust trimpot VR1 to bring it back to 260V. That's the only adjustment you may need to make.

If you want to make sure that the preamp circuit is working correctly, carefully disconnect the DMM from the HT supply **(don't touch the probes or clips, because 260V DC can give you a nasty shock!)** and use it to measure the plate voltage on each section of the 12AX7. You can measure these voltages at the plate ends of each 100kΩ 1W plate load resistor, with the DMM's negative lead connected to the preamp's earth. You should measure about +160V on each plate.

You can also measure the voltage across each 1kΩ cathode resistor, with the DMM now set to a lower DC range.

Where To Buy A Kit

A complete kit of parts for this design is available from Jaycar Electronics for $89.95. In addition, Jaycar will be selling a kit for preamplifier board only (includes the preamp PC board, all parts and the valve) for $59.95. Note: copyright of the PC boards associated with this design are owned by Jaycar Electronics.

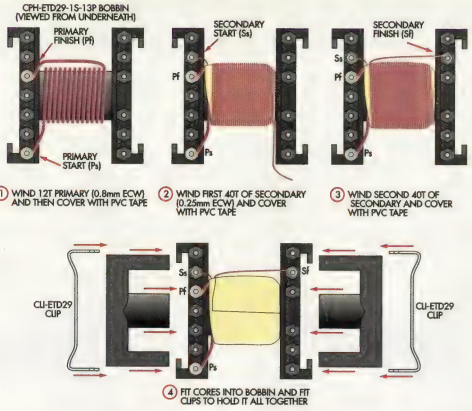
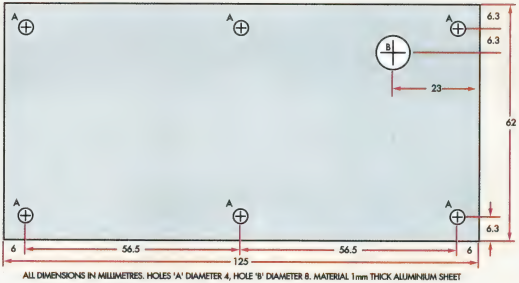


Fig.12: these diagrams show how the converter transformer is wound. The primary is wound on first, followed by two layers of the secondary.

Fig.13: this diagram shows the dimensions of the metal shield plate.



12AX7 VALVE PREAMP: SHIELD PLATE DETAIL

You should find about 1V DC across each one, verifying that each section of the 12AX7 is drawing about 1mA of plate-cathode current.

If all these voltages seem OK, your preamp should be working correctly.

High voltage protection

Now that you've checked all the voltages, it remains to provide a some protection against accidental electric shock. **Since the HT voltage is around +250V, it is possible to get a bad shock if you simultaneously touch the plate resistors and the earthed RCA connectors.**

With that in mind, we strongly suggest you put a generous coating of silicone sealant over the two 100kΩ 1W resistors, the 8.2kΩ resistor and the HT connection on the screw terminal block (be sure to cover both the top and the side entry point).

Now all that should remain is connecting its input to the pickup of a guitar or other instrument and its output to your power amplifier, recorder or mixing desk. Then you can hear for yourself what "valve sound" actually sounds like. **SC**

SERVICEMAN'S LOG

The JVC TV set that whistled

After many years in the same premises, we recently moved to something newer and bigger so I now have a lot more workshop space than before. And you need plenty of space these days because the TV sets are getting bigger.

Moving premises can be a real pain in the you-know-what but the move really has been worthwhile. Among other things, it gave me the chance to throw out a lot junk and other stuff that I didn't need, so that I can now work in an uncluttered environment.

It's amazing how much stuff you can accumulate in this business over the years and I really welcomed the excuse for a good "chuck out". Of course, I kept all the real treasure – you never know when it might come in handy!

The whistling JVC

Mrs Blandford complained that her 59cm JVC AV-G25AU (MZ2 chassis) had no picture and "whistles". On the face of it, I thought that this might be quite interesting because I had never heard a TV whistle before. In reality, the set was actually pulsating and gave out a protesting noise that very loosely could be described as whistling.

Having repaired a troublesome AV-G21AU some months ago, I had a good idea what the problem was. The line output transistor (Q522, 2SD1878-YD) was short circuit and the usual cause was dry joints on blue ceramic resonator CF561.

I dutifully replaced the transistor, resoldered the resonator and, fully confident of the outcome, switched the set on. I then confirmed that all was Mickey Mouse and went to have a cup of coffee. When I returned 20 minutes later (I don't like to be rushed over sacred rituals), I was mortified to find that the set had rejoined the choir and was pulsating just as before.

So what had gone wrong? I installed another expensive transistor and then began resoldering the set in an effort to cure the fault. However, what I didn't realise was that the switch-mode power supply reservoir capacitor (C910) remained charged at +295V for a very long time after the fault had occurred. As I worked on the set, my arm suddenly strayed across this vindictive component and yes, you guessed it – it bit me!

That 295V on my otherwise pristine arm was very painful but worse still, the solder I was carrying fell out of my hand and shorted out parts of the power supply. This resulted in a short fireworks display, even though the set had been turned off for quite a while.

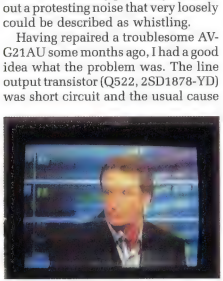
When the smoke cleared, and after I had checked the obvious, I found that the power supply no longer whistled. It fact, it couldn't do anything at all – except give me another shock, if I was stupid enough to try. I wasn't – instead, I discharged the beast using a globe before carrying out a series of DC voltage checks on the circuit.

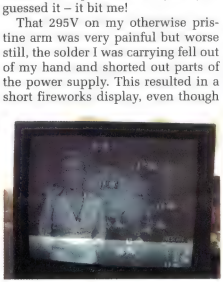
Eventually, I discovered that Q901 (2SD1853-T) and D908 were leaky. The former is a special Darlington pair and the latter a 7.5V zener diode. I had to order the transistor in but after I had fitted them both, the set was still dead.

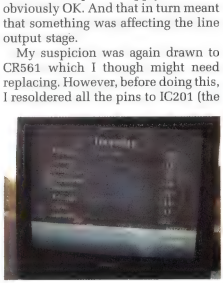
Remembering to discharge the capacitor again, I then replaced IC901 (STR-S6707), after which the set agreed to fire up. This time, with my hand near the master on/off switch, I waited to see if there was anything untoward that was causing the destruction of the line output transistor. A few minutes later, the set started to make noises and the picture began to tear.

During this time, the +114V at test point TP91 remained constant on my DMM, so the power supply itself was obviously OK. And that in turn meant that something was affecting the line output stage.

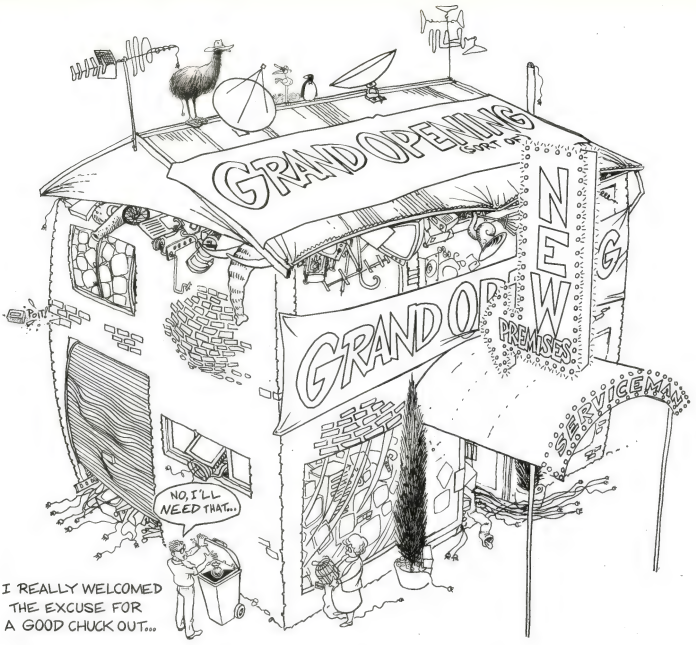
My suspicion was again drawn to CR561 which I though might need replacing. However, before doing this, I resoldered all the pins to IC201 (the







These emailed pictures proved that one customer's TV set really did have a problem!



jungle IC), paying particular attention to pins 14 & 17 which are adjacent to the crystal.

This finally fixed the problem and Mrs Blandford was able to have her "telly" back after a good long soak testing.

Email in the fault

Amongst all the huge technological changes within this industry that happen daily, a slightly novel approach to reporting faults has arisen which I suspect will take off and be the way of the future.

A 1990 Philips 25GR6765/75R (G110-S chassis) appeared on my bench with a fault description "Intermittently, the top disappears when changing channels". So I switched it on, expecting a vertical linearity fault.

This set is well known and, although rather ancient these days, is not considered difficult to repair. In addition, you get used to the terrible and widely varying fault descriptions from clients, so you never quite know what to expect.

Well, I waited and waited but nothing happened. The picture was excellent considering the set's age, so I put it to one side but still within visual range while I got on with other jobs.

After three weeks, the set hadn't so much as blinked incorrectly and I put the "fault" down to either an antenna problem, or bad connections or interference. And so the set was returned to its owner with a note to that effect.

Days later, I got an email with a set of attachments. Apparently, it played up about 24 hours after going home and to prove it, our enterprising client had photographed the effects with his digital camera.

The photographs were quite clear, although the cause of the fault wasn't.

Items Covered This Month

- JVC AV-G25AU 59cm (MZ2 chassis).
- Philips 25GR6765/75R (G110-S chassis).
- Panasonic TX-33V30X (M16MV3 chassis).
- Grundig M82-4986/9S/PIP (CUC 3840 chassis).

had melted a gap of about 0.25mm in the middle, which is barely visible to the naked eye. Replacing this fuse was all that was necessary in that particular set.

Sometimes R601, R602 and R611 also fail. The BG-2S is more reliable but has a ceramic capacitor (C820, 1000pF 2kV) across the line output transistor which sometimes fails.

TV set sizes

When I refer to a large 80cm or 34-inch television, please bear with me, as these sorts of numbers can be confusing. For example, if a picture tube carried a label that read "M78KPH-566X", you used to be able to rely on this as meaning that the viewable diagonal was 78cm. However, the manual for the Panasonic TX-33V30X set (M16MV3 chassis) that uses this tube states that it is a "type 33 (84cm) measured diagonally".

Other manufacturers use the imperial system and call it a 33-inch set. Because of these differences, I can only generalise and quote the advertised size where I can find it.

Anyway, there I was with another large heavy (60kg) "telly" on the bench (what do one-man-show TV repairers do about moving these? No wonder when we get old we all suffer from bad backs and poor eyesight!).

The picture and sound were great off-air but on AV there was little colour and no luminance. Instead, there was an effect I can only describe as like "shooting stars"! These appeared as lines with a bright spot at the end on the lefthand side – very bizarre.

I decided to start with the AV input "U Board" and trace the video signal with a CRO into the "C Board" (AV Control). The only trouble was access – basically, there was none! Fortunately, I had a set of extension cables and when I finally had the "C Board" out on the bench with the CRO probe in my hand, I switched the set on.

Unfortunately, the fault had now disappeared and the set was showing the colour bars perfectly. After examining it for dry joints, I refitted the module into the set to see if the fault would reappear. This was going to be tricky to get to the bottom of because it really needed to be in the set to give the fault.

I persevered again with the module on the bench (with the extensions) and tried to recreate the fault. It looked as though a component on the "C Board" was radiating an interfering cross-modulating signal. I ran my moist fingers all over the board and noticed that when I touched an area near the bottom corner (from IC3003 to the C1 plug corner), the fault began to recur.

I tried to nail it down but it wasn't possible with my big fingers, so I used a small screwdriver instead to pinpoint different components.

I started at "A/V 3.58/Other" analog switch IC3003 (TC4066) and found pins 6, 8, 11 & 12 to be sensitive, but it got more so when I touched the base of Q3039 and even more so when I got down to Q3046 (UN4213).

The latter is a surface-mount NPN transistor (with inbuilt 47Ω resistors in its base and emitter circuits), which controls the switching signal to the IC. Replacing this transistor and refitting the module fixed the problem.

A slow Grundig

A Grundig M82-4986/9S/PIP (CUC 3840 chassis) was brought into the workshop with the complaint that it was slow to come on.

Once I got the back off, I connected a true RMS heater meter to the heater filament pins (9 & 10) of the A76-JTS90X03 picture tube and, as I suspected, the voltage was very low (about 3.5V) at switch on. However, there was also a noise coming from the motherboard, which suggested that something was under stress.

Next, I measured the main voltage rail (A) from D656k. This was spot on at +152V and as I was watching, the noise stopped and the heater voltage moved up to 6.3V. However, the "A" rail remained constant. This told me that the switchmode power supply was OK and so my attention moved to the deflection stages.

This set uses IC550 (TDA8140) as the horizontal driver and it goes direct to the line output transistor. It is fed by a + 12V rail to pin 2 and right next to it is a 100µF electrolytic filter capacitor (C507). Its cover had peeled back and it looked highly suspect. I froze the capacitor when the set was running normally and immediately the noise returned and the picture dimmed.

Replacing it fixed the problem completely. **SC**

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Our best LED TORCH... EVER!

By JOHN CLARKE

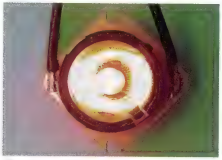
This new LED torch blasts our previous LED torches into the weeds. It is much brighter, gives a beautifully diffused beam and is far more efficient than any torch globe. The batteries will also last much, much longer. It can be easily built into a readily available 2 D-cell torch.

Our new LED torch uses the Luxeon STAR/O 1W white LED which comes with its own collimating lens assembly.

We previewed the Luxeon 1W and the truly awesome 5W version in the May 2003 issue and this torch is the first of a series of drive circuits for the 1W version.

In the last 12 months LED torches have finally arrived. This white LED torch provides a similar light output to its incandescent bulb counterpart yet uses far less current from the battery. It gives a beautifully soft light beam which maintains a constant colour and similar brightness over the whole battery life. And the LED should never need replacing.

Compared with a typical conventional torch, this LED torch has a much wider and more evenly distributed beam. Torch bulbs typically have a very small bright spot with weak diffuse light surrounding it.



The heart of the new torch: a Luxeon STAR/O 1W ultrabright LED.

The white LED torch provides a beautifully even distribution of light which can light up a fence gate (or whatever) at more than 15m. At this distance the beam is about 5m in diameter.

Apart from its sheer light output, this LED torch provides produces a natural white light instead of the yellowish light from torch bulbs.

And it continues to produce this constant white light regardless of the battery condition, until they are virtually flat.

High efficiency

These new white LEDs are much more efficient than torch bulbs. The Eveready KPR102 Krypton light bulb

Parts List – 1W Star LED Torch

1 Eveready 2 D-cell WP250 waterproof torch (KMart)
1 Luxeon 1W white STAR/O LED (LXHL-NW98) (Alternative Technology Association)
1 PC board coded 11211031, 33mm diameter (RCS Radio Pty Ltd)
1 Ringgrip mains bayonet lamp holder skirt (LH19/RB-WE) (KMart)
1 32mm diameter tinplate disk (or brass)
1 22µH 3A axial choke 7mm diameter x 26mm long (Epcos B82111-E-C22) (Farnell 608-671)
1 PC stake
4 M2 x 6mm screws
1 50mm length of red hookup wire
1 50mm length of black hookup wire

Semiconductors

1 ZXSC100N8 Zetex DC-DC Converter SO8 package (IC1) (Farnell 384-7962)
1 ZXT13N20DE6 Zetex low Vcesat NPN Transistor (Q1) (Farnell 334-6870)
1 BC559 transistor (Q2)
1 ZHCS2000 Zetex Schottky diode (D1) (Farnell 411 5843)

Capacitors

2 220µF 10V Rubycon ZL series Ultra Low Impedance electrolytic (Farnell 768-080)
1 1nF ceramic capacitor (code 102 or 1n0)

Resistors

1 33 milliohm 1W surface mount resistor (R033) (Welwyn LR series 2010 case) (Farnell 361-0238)
1 22kΩ 0.063W surface mount 0603 case resistor coded 223(Farnell 911-392)
1 3.3Ω 0.063W surface mount 0603 case resistor coded 3R3 (Farnell 357-1130)
1 100kΩ miniature horizontal trimpot coded 105 (VR1)
1 0.1Ω 5W resistor (for setting up); coded 0R1

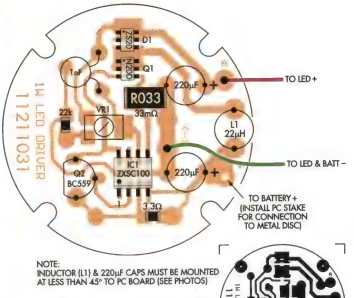
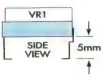
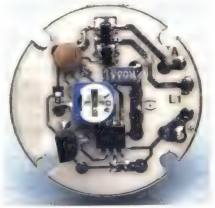


Fig.2 (above): because this is such a tiny PC board, we have shown the overlay above twice normal size. Fig.3 (right) shows the PC pattern at 1:1 scale while the photo below of the nearly-completed PC board is slightly larger than life-size. The trimpot (VR1) needs to have its legs bent under and trimmed to allow it to mount low enough on the PC board, as shown in the diagram below (Fig.4).





This photo is similar to the one above but is now complete with the inductor (L1) and two electros soldered in place. Note that these components are neither vertical nor horizontal –they must be "crammed in" as flat as they can go to allow the PC board to fit in place.

by the 220µF capacitor to provide DC to the LED.

Losses in this conversion are mainly in the inductor, the switching transistor Q1, current sense resistor R1 and the diode D1. Efficiency will be high if we can minimise these losses.

Since the inductor current is limited to 0.53A (peak) while it is rated at 3A, it will not saturate and will therefore have minimal heating losses. At the same time, transistor Q1 is a low saturation device. Its collector emitter voltage is a maximum of 45mV at 1A which means that there will be little power loss in this device.

R1, the current sensing resistor has a value of only 33mΩ (33 milliohms) so the maximum voltage drop when the inductor current reaches 0.53A is a mere 17.5mV.

Power dissipation in this resistor is so low that even with a constant 0.53A through it, the power would be less than 10mW. In practice, it will be less than 5mW.

Losses in diode D1 are kept to a minimum because it is a Schottky type with a rated 385mV forward voltage at 1A. Further efficiencies in the conversion are due to the very low quiescent current drain of IC1 at less than 300µA, and the way Q1 is driven.

Transistor Q2 is used to boost the current drive to the base of Q1. IC1 senses the voltage across the 3.3Ω resistor at Q2's emitter and limits current flow to around 7.5mA into Q1's base.

Q2 therefore operates as a current source providing the base current to

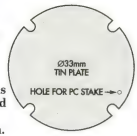


Fig.5: you'll need one of these tinplate discs – use this diagram (or the PC board itself) as a template and cut the disc from a tin can.

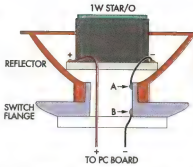


Fig.6: here's how the LED sits in the reflector. The cathode (black) wire (only!) is soldered to the flange as shown.

Q1. When the Vdrive output of IC1 at pin 8 goes to ground, the base drive to Q1 is off and so the transistor switches off, allowing L1 to deliver its power to the load via diode D1.

The output power delivered to the 1W LED is related to the peak current in L1, the switching frequency and the difference between the input voltage and the voltage across the LED.

The power is regulated using the sense resistor R1 to detect peak current and by sensing the voltage across the LED.

VR1 and the 22kΩ resistor divide the LED voltage down and feed it to the FB (feedback) input, pin 6 where it is compared to an internal voltage reference which is around 730mV (nominal).

Heavy switching currents drawn from the battery and delivered to the load are smoothed out using low impedance capacitors.

Note that good efficiency of the conversion is also dependent on the low effective series resistance (ESR) of the decoupling capacitors. We have specified two 220µF 10V ZL series capacitors from Rubycon. These have an ESR of 130mΩ at 100kHz.

You could improve efficiency slightly by using the ZA ultra-low impedance 220µF 10V Rubycon capacitors with 44mΩ impedance instead. However, these cost around ten times more than the ZL series!

Construction

The 1W LED torch is installed into an Eveready WP250 water-proof torch which uses two D cells. We have designed a PC board (coded 11211031) measuring 33mm in diameter to mount the DC-DC converter components. Note that all components mount on the copper track side of the PC board, opposite to what you would normally do.

At the time of writing, none of the kitset suppliers had decided to make a kit available for this project. However, the parts can be obtained from the suppliers mentioned below.

You can obtain the 1W LED from Alternative Technology Association, PO Box 2001, Lygon St North, East Brunswick, Vic 3057. Phone (03) 9388 9311; Fax (03) 9388 9322; website **www.ata.org.au**. Parts listed with a Farnell catalog number can be obtained from Farnell. Phone 1300 361 005; Fax 1300 361 225; website **www.farnellinone.com**.

The PC board can be obtained from RCS Radio Pty Ltd, 41 Arlewis Street, Chester Hill, NSW 2162. Phone (02) 9738 0330; Fax (02) 9738 0334; website **www.cia.com.au/rcsradio**.

Begin construction by checking the PC board carefully. The board should be circular as shown and may need to be cut and filed to shape first. Check for any possible shorts or undrilled holes. The PC board only has five holes, four for the mounting screws and one for the PC stake. The mounting holes can be drilled out to 2.5mm in diameter or you can file the hole in from the edge of the PC board to form an elongated slot.

The three main semiconductor devices are small surface mount types which should be soldered in first. The orientation for these is shown in the overlay diagram of Fig.2, with the labelling oriented as shown.

To solder these in, you will need a fine tipped soldering iron and a magnifying glass. Place one of these parts in position and solder one outside pin first. Check that it is oriented correctly and that the remaining IC pins lines up with the tracks on the PC board. When correctly lined up, solder the remaining pins. Now solder in the other semiconductor devices in a similar manner.

Next, solder in the 33mΩ resistor

Start the lens assembly by feeding the LED leads through what was the lamp hole in the reflector. The cathode (black) wire needs to be soldered to the threaded section, as shown above.

Next goes the bayonet lampholder skirt which we removed earlier and cut down to 16mm deep. The lampholder (and of course the lamp itself) are not used – that's the whole point in making this very efficient LED conversion!

Finally the assembled PC board is secured into position. This already has the tinplate disc soldered to it, with the whole assembly ready for mounting inside the torch body. The torch switch will still work and battery position will be the same.

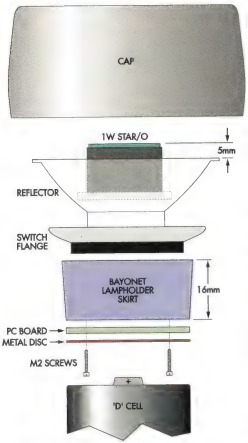


Fig.7: and finally, here's how the various pieces fit together in the torch.

and the other surface mount resistors. Note that the 3.3Ω and 22kΩ resistors can be standard 0.25W resistors instead of surface mount types and provision has been made to install these with an extra circular pad allocated and spaced for the extra resistor length. All components must be installed on the copper side of the PC board, except for the +3V supply PC stake.

Trimpot VR1 is mounted by bending the leads as shown in Fig.4, so that they contact the PC pads allocated for this component and soldering in place. The remaining components are installed by soldering the leads to the copper pads.

Keep components below 12mm above the PC board. The capacitors and inductor need to be bent over as shown in the photographs.

Cut out a 32mm diameter disk of tinplate from a tin can lid and place this on the back of the main PC board. Fig.5 shows the details. Drill a hole where the PC stake fits through and solder this tinplate disk in place. Cut the PC stake flush against the tinplate. Also drill and file out the four mounting holes.

As mentioned, the LED torch is built into a standard Eveready WP250 water-proof torch. The reflector needs to be removed from the lens cap so that the 1W LED can be installed.

To remove the reflector, scrape around the inside of the lens cap where the reflector sits, to remove the plastic that has been heat welded to the reflector. We used a flat screwdriver and scraped away till the reflector came loose.

The 1W LED assembly will require a small amount of filing at each corner base so that it will sit comfortably within the reflector and no more than 5mm above the reflector lip. This is to prevent the LED assembly making contact with the inside of the torch lens. Fig.6 shows how the Luxeon LED is installed and connected.

Note that if you install the LED in a different torch, you may need to drill four holes in the reflector so that each corner of the LED assembly can sit inside the hole.

The PC board is installed at the rear of the torch reflector assembly using a 240VAC bayonet lamp holder skirt. This is cut down to 16mm in height from the screw thread end and glued to the plastic flange at the rear of the torch reflector using super glue.

The PC board is placed over the rear of the bayonet lamp holder and the four holes are drilled 2mm in diameter for the securing screws.

Note that you will need to scrape away a little of the bayonet holder for the solder connections to sit into allowing the PC board to sit flat against the rear of the holder.

Also mark the orientation of the PC board onto the bayonet lamp holder so that it will be installed with the same orientation each time. We used a red marking pen to show the correct orientation. Fig.7 shows these details.

Setting up

Wire the circuit up as shown but with a 0.1Ω, 5W resistor in series with the LED.

Set VR1 fully anti-clockwise and connect a multimeter across the 0.1Ω resistor set to read DC millivolts. Using a piece of wire, connect the two D cells to the torch (take care to get the correct polarity) and adjust VR1 for a reading of 35mV. Then remove the 0.1Ω resistor and finish wiring.

Attach the PC board to the bayonet lamp holder skirt with the M2 screws. Assemble the torch together, making sure the batteries are placed in with the positive side up. **SC**

It's finished! This photo is taken "turned off" so you can see at least some of the detail inside the lens. Our modification turns the very nice Eveready WP250 Torch into a sensational model! We thought our previous LED torches were good – but with the newLuxeon 1W LED this is by far the best one ever.

Massive Birthday Sale

November 03 ISSUE

4 in 1 Battery Free Universal Remote Control

NEW

Pre-programmed for thousands of devices, it has a built in dynamo that charges the internal cell to run the unit. Just a few easy turns per day is all that is needed to keep the remote charged.

- Measures 210 x 55 x 30mm.

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128MB USB Flash Disk with MP3 Player

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A USB flash memory disk, and MP3 player in one! It stores up to 2hrs of MP3 music, and requires no software (drivers included for Win98SE). Includes lanyard and earphones.

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- Measures 76 x 37 x 16mm.

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Valve Audio Pre-Amp Kit

NEW KIT

Ref: Silicon Chip Nov 2003. AT LAST! A valve based preamp kit! It uses a 12AX7 valve, and offers excellent performance. Kit supplied with PCBs, case, valve, ferrite cores, bobbin and clips, and all electronic components. Requires 12VDC @ 250mA.

Cat. KC-5370 $89.95

Valve Preamp Add-On Kit

NEW KIT

Ref: Silicon Chip November 2003. Add to KC-5370 for a stereo valve preamp. Powered from KC-5370, so no extra power is required. Kit supplied with PCB, valve, and all electronic components.

Cat. KC-5371 $59.95

Dual SIM Card Adaptors for Mobile Phones

NEW

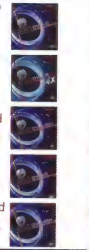
If you have multiple SIM cards with different carrier networks, then you need one of these. They allow you to hold two SIM cards in your phone, and switch between them, taking the strain out of changing SIM cards. The electronic 'switch' is simply operated by switching the phone off, then on.

Adaptor to suit Nokia 3310 - XC-5140*
Adaptor to suit Nokia 8310 - XC-5142
Adaptor to suit Nokia 8210 - XC-5144
*XC-5140 requires manual switching also.

Cat. ALL TYPES $14.95

New FORTIS Recordable DVD's

Great new recordable media at an excellent price!



DVD-R 1x Write Speed
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DVD+RW 2x Write Speed
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Animated Singing Birds

NEW

This delightful product consists of two birds (about finch size), perched on a plastic, but realistic looking piece of branch. When a person walks past, the birds burst into song. Not only do they twitter away to each other, their beaks move, as well as their tails. Uses 1 x AAA battery (not included)

Cat. LA-5013 $14.95

Animated Singing Finch in Cage

NEW

With real feathers and 360° motion, this little bird looks and acts almost like a real finch. The cage features a motion sensor underneath telling it when to start its routine. Mount it in the entranceway at your home or office to announce your arriving guests.

- Cage size 180(h) x 125(dia)mm.
- Uses 2 x AA batteries (not included).

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NEW

0.5W Transceiver with CTCSS – Sub Channel Calling

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- Uses 4 x AAA batteries (not supplied).
- 38 sub call channels.
- No licence required.
- See below for optional accessories.

Cat. DC-1030 $79.95

High Power 1.5W Transceiver

Up to 8km line of sight range! These transceivers are for serious users. They offer a host of features including a backlit LCD, voice activation, key lock, and much more. It is lightweight, very portable, and with the extra long range, it won't let you down. It is ideal for use in many professional areas such as electrical installation or building, leisure activities such as hiking or climbing, or anywhere constant communication is necessary.

- Uses 4 x AAA batteries (not supplied).
- No licence required.
- High and Low power setting.
- See below for optional accessories.

Maximum Legal Power!

Cat. DC-1040 $119.00

DUE LATE NOVEMBER

Optional Accessories Available:

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Use Ni-MH batteries and charge them while inside the transceivers.

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Use Ni-MH batteries in the transceivers and charge them in your car.

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Utilise the VOX function for complete hands free communication.

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The video splitter takes the computers video signal and sends it to two analogue monitors. Ideal for test bench applications, presentations etc. Supports VGA, SVGA, XVGA and Multi-Sync.

Specifications:
- Input 15 pin D male.
- Outputs 15 pin D female.
- 350 MHz video bandwidth.
- Max resolution 2048 x 1536 @ 60Hz.
- Size: 72(W) x 43(H) x 121(L)mm.

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- PS/2 connection.
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RF Wireless Scroll Mouse

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An easy PC networking solution. Drivers and software supplied.

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Link 2 computers together.

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- Provides a very high level of security.
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All leads are fully approved, and are the standard blue colour.

They are supplied in packs of either 2 or 5. Packs cannot be mixed for discount.

CHEAP Priced Way Way Below Normal. Limited Quantity, Stock up Now! **CHEAP**

Cat.	Length	Pack Qty	1 Pkt	4 Pkts	10 Pkts	Cat 5e/ea
YN-8181	1.0m	5	$11.95	$10.70	$9.50	$3.95
YN-8182	1.5m	5	$13.95	$12.35	$10.95	$4.50 approx
YN-8183	2m	2	$7.50	$6.75	$5.95	$5.25
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- Use USB devices on older PCs not equipped with the technology.

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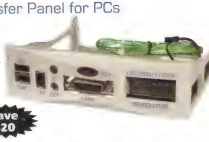

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Cat5e Patch Leads

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All colours (ea)	Was $3.25	Now $2.25	Save $1

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3.0m

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5.0m

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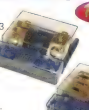

Wafer Style Fuse Block

1 x 2 gauge in, and 2 x 4 gauge out.

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vifa 5" Screened Woofer/Mid Driver

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- Great used in 2 and 3 way systems.

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6.5" RESPONSE Kevlar Cone Woofer

- Long throw, butyl rubber surround.
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- Large freq. range: 35Hz – 5000Hz
- See website for details and specs.

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- Dual magnet & voice coils.
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12" XL Series RESPONSE Subwoofer

- 200WRMS power handling.
- Dual magnet and voice coils.
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10" Venom Subwoofer

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- 4 Ohm impedance.
- Dual magnet.

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- Internal 6V 4Ah SLA battery.
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- Two internal 6V 4Ah SLA batteries.
- Mains and car charger supplied.
- 170mm lens dia.

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High Quality LED Torch

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- Uses a 9V battery (supplied).
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- Look just like a real sparkplug.
- Super bright LED.
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- Water resistant case.
- Backlit LCD screen.
- Very limited quantities, may be store display model.

Save $50

Was $349.00

Cat. DC-1050 $299

Waterproof Camping Table Lantern

- Comparable light output to a 60W globe.
- Waterproof, and even floats.
- Limited quantity.

Was $27.95

Save $8

Cat. ST-3035 $19.95

LED Stretch Light

- Operates as a torch, or lantern.
- Limited quantity.

Was $14.95

Save $5

Cat. ST-3075 $9.95

White Electroluminescent (EL) Wirelight

- Glows evenly over its entire length.
- 1m long
- 12 VDC powered
- Limited quantity.

Was $34.95

Save $10

Cat. SL-2835 $24.95

Portable Gooseneck Table Lamp

- Rotary on/off switch with dimmer.
- Limited quantity.

Save $10

Was $44.50

Cat. SL-2802 $34.50

16W 12VDC Twin Fluorescent

- Fitted with 2 x 8 Watt tubes.
- Similar light output as a 60W globe.
- Limited quantity.

Was $29.95

Save $5

Cat. ST-3020 $24.95

12V Twin Blue 12" Neon Highlight

- Can be mounted individually or in the supplied base.
- Limited quantity.

2002 Cat Price $75.95

Save $30

Cat. ST-3134 $45.95

Digital Compass with Clock & Thermometer

- Hand held or suction cup mounted.
- Self calibrating.
- Backlit LCD.

Was $59.95

Save $15

Cat. QM-7262 $44.95

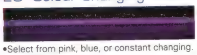
20" Colour Changing Neon

- Select from pink, blue, or constant changing.
- 12 VDC powered
- Limited quantity

Was $64.95

Save $17

Cat. ST-3138 $47.95



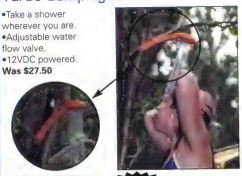
Turbo Camping Shower

- Take a shower wherever you are.
- Adjustable water flow valve.
- 12VDC powered.

Was $27.50

Cat. YS-2800 $24.50

Save $3



500,000 Candle Power Spotlight

- Made from high impact ABS plastic.
- Supplied with mains and car charger.
- Limited quantity.

Was $29.95

Save $10

Cat. ST-3310 $19.95

1,000,000 Candle Power Spotlight

- Made from high impact ABS plastic.
- Supplied with mains and car charger.
- Limited quantity.

Was $49.95

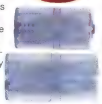
Save $20

Cat. ST-3315 $29.95

Battery Adaptor Sleeve Set

Only got a couple of AA batteries when you need a few D's? These battery sleeves turn smaller cells into larger ones so that you can use the batteries you have in the device you need to get running. With extremely high capacity Ni-MH cells now available, it is very feasible to use small cells in larger appliances, saving you $$$. Supplied as a pack of 2 sleeves to adapt:
AA into C / C into D.

NEW



DUE LATE NOVEMBER

Cat. PH-9295 **$8.95**

Kingcell Alkaline Battery Bulk Packs

Buy in Bulk and Save! Contains 24 Alkaline batteries. 2 sizes available.
Virtually wholesale prices!

Handy-for-powered-little

24 x AA Cat. SB-2330
Our AA Kingcell's sell for 99c ea in a pack of 4, these are only 54c ea!
Save 45c ea!

24 x AAA Cat. SB-2331
Our AAA Kincell's sell for $1.13ea in a pack of 2, these are only 54c ea!
Save 59c ea!

Both Sizes **$12.95**

Great Savings on Hobbyist Plugpacks

These plugpacks are great for experimental work. Save this month! *Limited quantity.

10VDC @ 1.2A
Was $16.45
Cat. MP-3005 **$4.45** Save $12

9VDC @ 850mA
Was $14.95
Cat. MP-3009 **$3.95** Save $11

High Capacity Battery Pack Replacement Cells

Used in many rechargeable battery packs, for a large range of portable appliances such as drills, electric toothbrushes etc.

NEW

Type	Cat	1+	10+	20+
4/5A - 2000mAh	SB-1719	$9.95	$8.75	$7.75
4/3A - 3500mAh	SB-1711	$14.95	$13.35	$11.70
Sub C - 2700mAh	SB-1613	$8.95	$7.95	$6.95
Sub C High Discharge 2400mAh	SB-1617	$8.95	$7.95	$6.95
D - 9000mAh (Nipple Cap)	SB-2462	$27.90	$24.95	$21.95

Save on Ni-MH Rechargeable Batteries

Type	Cat	Was	1+	10+	20+
AAA 800mAh Nipple	SB-1720	$3.59	$3.15	$2.75	$2.35
AAA 800mAh Tags	SB-1722	$3.78	$3.30	$2.95	$2.55
AA 1200mAh Nipple	SB-1730	$2.95	$2.60	$2.30	$2.00
AA 1200mAh Tags	SB-1732	$3.25	$2.90	$2.60	$2.30
AA 2000mAh Nipple	SB-1706	$5.95	$5.25	$4.75	$4.25
AA 2000mAh Tags	SB-1708	$6.25	$5.50	$4.95	$4.45
C 4500mAh Nipple	SB-2429	$14.95	$13.35	$11.70	$10.70
D 8000mAh Nipple	SB-2449	$24.90	$22.35	$19.70	$17.90
4/5A 1800mAh Tags	SB-1718	$8.95	$7.95	$6.95	$5.95
4/3A 3000mAh Tags	SB-1710	$12.95	$11.35	$10.35	$9.35
Sub C 2700mAh Tags	SB-2447	$8.95	$7.95	$6.95	$5.95

MASSIVE INVERTER SALE!!!

Modified Square and Pure Sine Wave Inverters Discounted! All feature a pushbutton on/off switch, overload protection, LED power indication, and electrical isolation between the battery and secondary voltages for safety. Many other units do not have this safety feature.

Pure Sine Wave

150W (300W Surge) 12VDC to 230VAC
MI-5080 Was $299 Now $249 Save $50

300W (500W Surge) 12VDC to 230VAC
MI-5082 Was $379 Now $319 Save $60

500W (1000W Surge) 12VDC to 230VAC
MI-5085 Was $469 Now $399 Save $70

1000W (1500W Surge) 12VDC to 230VAC
MI-5090 Was $1099 Now $959 Save $140

1500W (2500W Surge) 24VDC to 230VAC
MI-5095 Was $1395 Now $1195 Save $200

Modified Square Wave

100W (200W Surge) 12VDC to 230VAC
MI-5058 Was $89.50 Now $79.50 Save $10

140W (450W Surge) 12VDC to 230VAC
MI-5060 Was $109.50 Now $94.50 Save $15

300W (900W Surge) 12VDC to 230VAC
MI-5062 Was $159.50 Now $139.50 Save $20

400W (1200W Surge) 12VDC to 230VAC
MI-5064 Was $199.50 Now $169.50 Save $30

400W (1200W Surge) 24VDC to 230VAC
MI-5065 Was $199.50 Now $169.50 Save $30

600W (1500W Surge) 12VDC to 230VAC
MI-5066 Was $299 Now $249 Save $50

800W (2000W Surge) 12VDC to 230VAC
MI-5068 Was $389 Now $329 Save $60

1000W (2400W Surge) 12VDC to 230VAC
MI-5070 Was $529 Now $439 Save $90

1500W (3000W Surge) 12VDC to 230VAC
MI-5072 Was $749 Now $649 Save $100

Great Savings on 12V Sealed Lead Acid Batteries

1.3Ah Was $24.95 Cat. SB-2480 **$18.95** Save $6

2.2Ah Was $32.95 Cat. SB-2482 **$24.95** Save $8

4.2Ah Was $39.50 Cat. SB-2484 **$29.50** Save $10

7.2Ah Was $39.95 Cat. SB-2486 **$29.95** Save $10

18Ah Was $69.95 Cat. SB-2490 **$54.95** Save $15

4 Amp Sealed Lead Acid Battery Charger

This great charger is mains powered, and supplies 4A (fast charge), or 300mA (trickle charge), to the heavy duty battery clips. It automatically switches to trickle when the battery is full, and features reverse polarity buzzer, and charge status LED.

Save $20

Cat. MB-3526 **$79.00**

10 x AA & AAA, Ni-Cd and Ni-MH Battery Charger

Computer controlled, it can charge up to 10 cells at one time. It features a discharge function, individual charge status, and a maximum charge timer cut out. Supplied with mains plugpack.

Was $69.95
Cat. MB-3512 **$59.95** Save $10

OVER 5,500 PRODUCTS IN STORE

Jaycar ELECTRONICS

AV Booster / Repeater Amp Kit

•Ref: Silicon Chip April 2003.
•Supports composite video, s-video, and stereo audio.
•Kit supplied with PCB, silk screened, pre-punched panels, and all electronic components.

Was $119.95

Cat. KC-5350 **$99.95**

Save $20

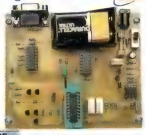
50MHz Frequency Meter Kit

•Ref: Silicon Chip October 2003.
•Very accurate, large 8 digit display.
•Kit supplied with PCB, laser cut silk screened panel, pre-programmed micro, and all specified electronic components.

Cat. KC-5369 **$69.95**

NEW KIT

Serial PIC Programmer Kit



NEW KIT

•Ref: Silicon Chip September 2003.
•Supports standard and 'in circuit' PIC programming.
•Kit supplied with PCB, and all electronic components.

Cat. KC-5367 **$39.95**

PC Infrared Remote Control Interface Kit for PC Based MP3 and DVD Players

•Ref: Silicon Chip August 2003.
•Interface with popular PC based DVD and MP3 player software.
•Kit supplied with PCB, and all electronic components.

Cat. KC-5366 **$39.95**

AC/DC Current Clamp Meter Kit for DMM's

NEW KIT

•Ref: Silicon Chip September 2003.
•A great alternative to expensive current clamp meters.
•Kit supplied with PCB, clamp, case, silk screened front panel, and all electronic components.

Cat. KC-5368 **$34.95**

Digital Instrument Display Kit for Cars

•Ref: Silicon Chip August 2003.
•Read many analogue based sensors as a digital display.
•Kit supplied with PCB, case, silk screened front panel, and all electronic components.

Cat. KC-5365 **$59.95**

'Smart' Slave Flash Trigger Kit for Cameras

•Ref: Silicon Chip July 2003.
•Triggers external flash systems for more professional photography.
•Kit supplied with PCB, silk screened front panel, and all electronic components.

Cat. KC-5364 **$29.95**

* Flash trigger lead not supplied.

Auto Power-Up Kit

•Ref: Silicon Chip July 03.
•Switches on associated equipment when a 'master' device is powered up.
•Kit supplied with PCB, silk screened front panel, and all electronic components.

Cat. KC-5363 **$79.95**

2A DC-DC Converter Kit

•Ref: Silicon Chip June 03.
•Step up 12V supply to between 13.8 and 24VDC.
•Kit supplied with PCB, silk screened front panel, and all electronic components.

Cat. KC-5358 **$49.95**

Experimenters/Educational Kits

These kits are designed to help experimenters understand the fundamentals of DC circuits, motors, generators, and bells. The kits are supplied unassembled, and use quality components to build the finished circuits. A user manual and experimental ideas are included. Great fun for ages 10 and up. •Limited quantity.

Bell and Light Kit 2 Kits in 1

Build an electromechanical bell from scratch, and learn the fundamentals of its operation. Combine the bell and light kit together to develop knowledge of light and sound for all sorts of circuits.

Save $6

Was $19.95

Cat. KJ-7040 **$13.95**

Motor and Light Kit 2 Kits in 1

Learn the basics of electric circuits, and the fundamentals of electric motors, and lighting circuits. Even the motor itself is supplied in knockdown form, so you can make it yourself!

Save $6

Was $19.95

Cat. KJ-7042 **$13.95**

Generator & Light Kit 2 Kits in 1

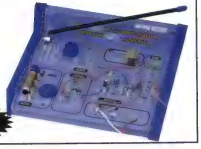
Build a simple dynamo to power the lighting kit, or one of the other kits in the range. A simple gearbox is included, and is assembled in its own plastic chassis.

Save $6

Was $19.95

Cat. KJ-7044 **$13.95**

AM/FM Experimenters Kit



Build a real AM/FM radio! This kit is more sophisticated than the others in the range, though construction is still straight forward, and it is clearly laid out to help the builder understand how they operate.

Save $10

Was $29.95

Cat. KJ-7048 **$19.95**

Video Enhancer/Stabiliser Kit

- Ref: Electronics Australia November 1997.
- Eliminate many unnecessary signals which can interfere with picture quality.
- Kit supplied with PCB, silk screened and punched panels, and all electronic components.
- Limited quantity.

Was $78.95 Cat. KA-1798 **$58.95** **Save $20**

Model Train Controller Kit

- Compact, low cost, and great for small layouts.
- Kit supplied with PCBs, case, silk screened front panel, and all electronic components.
- Limited quantity.

Was $55 Cat. KC-5304 **$45.00** **Save $10**

10 Channel IR Remote Control Receiver Kit

- Ref: Silicon Chip February 2002.
- Control appliances with ease, using only 1 remote control (not supplied).
- Kit includes PCB, pre-programmed PIC micro, and all electronic components.
- Limited quantity.

Was $49.95 Cat. KC-5326 **$39.95** **Save $10**

36WRMS Class H 12V Amplifier Kit

- Ref: Silicon Chip March 2002.
- Based on the Philips TDA1562Q IC, and delivers up to 70W (max) @ 4 Ohms.
- Kit supplied with PCB, heatsink, and all electronic components.
- Limited quantity.

Was $59.95 Cat. KC-5329 **$49.95** **Save $10**

Signal Injector

- Useful for testing audio and radio equipment.
- Square wave output at approximately 1kHz.
- Kit supplied with PCB, and all electronic components.
- Limited quantity.

Was $6.95 Cat. KG-9192 **$4.95** **Save $2**

Telephone Dialler for Burglar Alarms Kit

- Ref: Silicon Chip April 2003.
- Dial a pre-programmed number via modem when triggered by an alarm.
- Kit supplied with PCB, case, silk screened front panel, and all electronic components.

Was $65 Cat. KC-5348 **$50.00** **Save $15**

Television Masthead Amplifier Kit

- Ref: Electronics Australia June 1998.
- Save a fortune over buying a pre-built masthead amplifier.
- Kit supplied with PCBs, case, electrical conduit for amplifier housing, and all electronic components.
- Limited quantity.

Was $39.95 Cat. KA-1810 **$29.95** **Save $10**

Touch and/or Remote Controlled Light Dimmer Kit

- Ref: Silicon Chip January 2002.
- Highly responsive touch plate dimming with aluminium face plate.
- Kit supplied with PCB, pre-programmed micro, Philips brand high voltage resistors, Clipsal brushed aluminium face plate, and all electronic components.
- Limited quantity.

Was $69.95 Cat. KC-5324 **$54.95** **Save $15**

Multi-Mode Timer

- Microprocessor controlled.
- Seven different timing modes.
- Kit supplied with PCB, and all electronic components.
- Limited quantity.

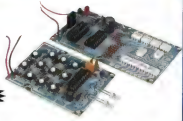
Was $42.95 Cat. KD-6017 **$34.95** **Save $8**

Simple 40dB Preamplifier Kit

- Boost an insufficient input signal.
- Uses an electret microphone, or line input.
- Kit supplied with PCB, and all electronic components.
- Limited quantity.

Was $13.95 Cat. KD-6056 **$9.95** **Save $4**

Ten Channel Infrared Remote Control Kit



- Operates up to ten devices.
- Thousands of possible uses.
- Kit supplied with PCB, and all electronic components.
- Limited quantity.

Was $49.95 Cat. KG-9198 **$39.95** **Save $10**

Multi Voltage Bench Power Supply Kit

- Ref: Silicon Chip April 2002.
- Selectable voltage, at up to 750mA.
- Kit supplied with PCB, case, silk screened punched panels, and all electronic components.
- Limited quantity.

Was $89.95 Cat. KC-5331 **$74.95** **Save $15**

Raucous Alarm Kit

- Ref: Silicon Chip February 2002.
- Sounds 8 tones at around 120bpm, it is impossible to ignore.
- Kit includes PCB, case, silk screened front panel, speaker, and all electronic components.
- Limited quantity.

Was $34.95 Cat. KC-5327 **$27.95** **Save $7**

Guitar Overdrive/Distortion Kit

- Ref: Silicon Chip May 2003.
- Adjustable distortion, tone, level, and a bypass switch.
- Kit supplied with PCB, silk screened front panel, and all electronic components.

Was $59.95 Cat. KC-5353 **$49.95** **Save $10**

OVER 5,500 PRODUCTS IN STORE
JAYCAR ELECTRONICS

Economy EQUATOR Car Alarm

Save $30

If you just want a simple alarm to protect your car, then this is it! Limited quantity.

What you get:
•Electronic blackbox controller.
•2 key fob remote controls. •Shock sensor.
•Bonnet pin switch. •Mini size siren.
•Ignition cut out relay. •Wiring looms.

Was $119.50

Cat. LA-8985 **$89.50**

Extra Remote Control Cat. LA-8986 $34.95

Full Feature EQUATOR Car Alarm

This is our 'Full House' alarm. It provides complete protection and also boot release (with optional solenoid). Limited quantity.

What you get: •Electronic blackbox controller. •2 key fob remote controls.
•2 stage shock sensor.
•Bonnet pin switch. •Ignition cut out relay.
•Backup battery siren. •Wiring looms.

Was $199

Save $50

Cat. LA-8955 **$149.00**

Extra Remote Control Cat. LA-8986 $34.95

Power Door Locking Kits for Cars

Add the convenience of central locking to your car. These kits can be used on their own, with suitable car alarms, or with our dedicated remote control unit (LR-8831 see website for details). Limited quantity.

2 Door

Supplied with 1 master and 1 slave actuator, control relay, and wiring loom.

Was $39.95

Save $15

Cat. LR-8838 **$24.95**

4 Door

Supplied with 2 master and 2 slave actuators, control relay, and wiring loom.

Was $59.95

Save $25

Cat. LR-8830 **$34.95**

YOUR LOCAL JAYCAR STORE

NEW SOUTH WALES	
Bankstown	•Ph (02) 9709 2822
Bondi Junction	•Ph (02) 9369 3899
Brookvale	•Ph (02) 9905 4130
Campbelltown	•Ph (02) 4620 7155
Erina	•Ph (02) 4365 3433
Newcastle	•Ph (02) 4965 3799
Parramatta	•Ph (02) 9683 3377
Penrith	•Ph (02) 4721 8337
Silverwater	•Ph (02) 9741 8557
St. Leonards	•Ph (02) 9439 4799
Sydney City	•Ph (02) 9267 1614
Wollongong	•Ph (02) 4226 7089
VICTORIA	
Coburg	•Ph (03) 9384 1811
Frankston	•Ph (03) 9781 4100
Geelong	•Ph (03) 5221 5800
Melbourne	•Ph (03) 9663 2030
Ringwood	•Ph (03) 9870 9053
Springvale	•Ph (03) 9547 1022
QUEENSLAND	
Aspley	•Ph (07) 3863 0099
Brisbane - Woolloongabba	•Ph (07) 3393 0777
Gold Coast - Mermaid Beach	•Ph (07) 5526 6722
Townsville	•Ph (07) 4772 5022
Underwood	•Ph (07) 3841 4888
AUSTRALIAN CAPITAL TERRITORY	
Canberra	•Ph (02) 6239 1801
TASMANIA	
Hobart	•Ph (03) 6272 9955
SOUTH AUSTRALIA	
Adelaide	•Ph (08) 8231 7355
WESTERN AUSTRALIA	
Perth	•Ph (08) 9328 8252
NEW ZEALAND	
Newmarket - Auckland	•Ph (09) 377 6421
Glenfield - Auckland	•Ph (09) 444 4628
Wellington	•Ph (04) 801 9005
Christchurch	•Ph (03) 379 1662
Freecall Orders	•Ph 0800 452 9227

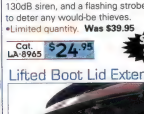
Steering Wheel Alarm

This handy unit requires no installation, and simply mounts on your steering wheel. It senses a breaking window, or any sharp jolt on your vehicle. A loud 130dB siren, and a flashing strobe help to deter any would-be thieves.
•Limited quantity. **Was $39.95**

Save $15

Cat. LA-8965 **$24.95**

Lifted Boot Lid Extender



Hold the boot lid of your car down safely while carrying oversized loads. The unit incorporates a strong retractable cable with metal carabineers which clip on and hold the boot lid down. Also features a retractable box cutting knife, and LED flashers. See website for details.

NEW

Cat. GH-1100 **$24.95**

All prices valid till 30th November 2003

EQUATOR Car Alarm with Remote Engine Start

This alarm allows you to start your vehicle at the press of a button. This means you can warm up your car before you drive off, savin wear and tear on your engine. Limited quantity.

What you get:
•Electronic blackbox controller.
•2 key fob remote controls.
•Shock sensor. •Bonnet pin switch.
•Mini size siren.
•Ignition cut out relay.
•Wiring looms.

Was $269

Save $60

Cat. LA-8995 **$209.00**

Gear Start Switch

Cat. LA-8997 **$39.95**

Equator Car Alarm with Remote Radio Pager

This alarm has all the main features of the full feature alarms, with the addition of a radio pager. The pager displays the alarm status, and has an effective range of up to 50m. Limited quantity.

What you get:
•Electronic blackbox controller.
•2 LCD key fob remote controls. •Shock sensor.
•Bonnet pin switch. •Ignition cut out relay.
•Backup battery siren.
•Wiring looms.

Was $399.50

Save $70

Cat. LA-8960 **$329.50**

Spare Learning LCD Remote Cat. LA-8962 $139.95

Switchmode 12V DC-DC Multi Voltage Converter

Output is switchable between 1.5, 3.5, 4.5, 5, 6, 9, and 12VDC regulated up to 1A. Supplied with 6 right angled DC plugs for compatibility with many devices.

Cat. MP-3028 **$24.95**

Rear View Mirror with Voice Recorder and Hands-Free Phone Kit

NEW

Turn an ordinary rear-view mirror into your car's communications centre. Built-in digital voice recorder and hands-free mobile phone kit. A loudspeaker is built in so the phone sound can be played through the speaker or via the retractable ear piece. See website for full details.
•Mirror width 270mm
•Power cable length 3M
•Phone cable 1.2M

Cat. GG-2120 **$89.00**

Rear View Mirror with Voice Recorder, Hands-Free Phone Kit and Reversing Sensor

Boasting the same great features as the rear view mirror to the left, with the addition of integrated parking sensors and distance display. Just install the mirror and the parking transducers. You will then have a four sensor parking monitor, which warns you of any objects behind your car, and even tells you how far away they are. See website for full details.
•Mirror width 270mm •Power cable length 3M
•Phone cable 1.2M •4 x Parking transducers included
•Transducer cable length 1.5M

NEW

Cat. GG-2122 **$189.00**

TECHSTORE MAIL ORDERS - FREE POST TO:
Reply Paid 6424. Jaycar Techstore Mail Orders. PO Box 6424, Silverwater NSW 1811

Jaycar ELECTRONICS

Freecall For Orders 1800 022 888

www.jaycar.com.au

OVER 6,500 PRODUCTS IN STORE JAYCAR ELECTRONICS

PRODUCT SHOWCASE

Altronics MP3 Player, Amp Kit

If you're looking for a way to "go mobile" with your MP3 music collection, then check out the new Altronics K2770 MP3 Player kit.

It works with a standard IDE hard disk drive, meaning it can store gigabytes of music – up to 10,000 tracks, in fact! The kit comes with a pre-punched and silk-screened metallic silver case, and includes a graphical LCD display along with an array of push-button switches for player control. You can even drive the beast with an infra-red remote control!

The DIN-sized case can house one 3.5-inch hard drive (not supplied), a pre-assembled MP3 jukebox PC board, LCD display module, front panel PC board and power supply PC board.

The MP3 jukebox PC board forms the core of the player. Its main functional components consist of a PIC micro, MP3 decoder and stereo D-A converter. Included on the board are connectors for an LCD module, IDE hard drive, power supply, switch inputs and stereo signal output. Almost all on-board components are surface-mounted, which probably explains why Altronics is supplying this part of the kit pre-assembled and tested.

The power supply and front-panel boards are supplied as kits of parts. These boards are relatively simple and assembly should not present too much of a challenge to those familiar with the pointy end of a soldering iron.

Internal wiring is surprisingly simple too, with the LCD module mounting "piggy-back" on the MP3 board. Hook-up to the hard disk drive is via a conventional 40-way ribbon cable.

The unit should work with most ATA-compliant IDE hard disk drives. For use in a car, a 2.5" laptop drive is mandatory as these are much more shock tolerant. However, you'll need to purchase a 3.5" to 2.5" adapter kit.

One negative is that the kit doesn't provide an easy way of transferring your MP3s onto the hard disk. You must physically remove the drive and plug it into an IDE port in your PC in order to get the files onto the drive. We would not recommend this to anyone unfamiliar with the internals of their PC.

Audio output from the player is via twin RCA sockets. The unit can be powered from a 12V DC regulated or 13.8V DC unregulated source.

Amplifier add-on

Altronics also offer a companion 15W stereo amplifier kit. With this add-on, all you need are two bookshelf-style speakers for a complete, stand-alone jukebox.

The amplifier is based around Philips TDA1519 amplifier modules, as used in the SILICON CHIP 12V Stereo Amplifier (May 2001). A single PC board carries all of the components, with the amplifier modules bolting up to a small heatsink at the rear of the case.

The kit is supplied with a look-alike pre-punched metallic silver case. Twin RCA sockets and an unregulated DC output is provided at the rear for connection to the player unit. Plug-in screw terminal blocks are used for the speaker connections.

Note that unlike the player, this unit is mains-powered. Mains input is via an IEC socket and a small (80VA) toroidal transformer.

Summary

The K2770 MP3 Player kit boasts a host of features that would make it useful for a variety of applications. With a DIN-sized case and 12V operation, it should work well as part of a monster car audio system. Using the automatic random play mode, it could also be used as part of a "canned music system", such as in a PA setup or as part of a "music on hold" service.

Specs at a glance:

- 122 x 32 graphical LCD
- Shuffle & sequential mode playback
- Stop/play/pause/next track/prev track/ skip/manual track selection
- Automatic random playback mode
- Supports multiple directories, ID3V1 tags and "artist-title" track naming
- Detailed track statistics shown on LCD
- Standard DIN sized case

Special pricing

The K2770 MP3 Player kit normally retails for $329, but is currently available at the special price of $299. This includes an A1013 infrared remote control. The K5101 Stereo Amplifier kit retails for $149.

Contact:
Altronic Distributors
PO Box 8350, Perth Business Centre,6849
Tel: 1300 797 007
website: www.altronics.com.au

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New DPO family from Tektronix

Tektronix, Inc. has announced the TDS700B family of new digital phosphor oscilloscopes (DPO) which feature the most advanced triggering, signal fidelity and analysis capabilities of any oscilloscopes on the market at comparable price points.

The 4GHz TDS7404B, the 2.5GHz TDS7254B and the 1.5GHz TDS-7154B provide more than 400,000 waveforms per second waveform capture display. Designers can implement data rates up to a Gigabit per second (1Gb/s) and rise times on the order of 100 picoseconds (100ps).

The TDS7000B Series DPOs waveform capture rate is orders of magnitude better than existing digital storage oscilloscopes (DSOs) in delivering faster accumulation of signal data for both critical insight into signal behavior and in-depth analysis.

Qualified triggers help designers hone in quickly on problems due to errors that are considered faults only when they occur after qualifying events or time. Other triggers include a broad selection of edge, timing, setup/hold, fault, and event triggers. This new trigger system features trigger jitter as narrow as 1.0ps RMS and the circuit can detect glitches as low as 110ps. The new DPOs uniquely address both hardware and software clock recovery by a new, continuously variable (1Mb/s to 3.125Gb/s) built-in hardware clock recovery circuit or by integrated software clock recovery tools, embracing the widest range of serial standards.

Contact:
NewTek Sales Pty Ltd
Tel: (02) 9888 0100
website: www.newteksales.com.au

Computer/Notebook USB TV box with FM radio

Want to watch TV (or receive FM radio) on your computer or notebook? Or play standard (composite) video (eg, from a VCR) on your computer? Just connect this nifty little device from Microgram to your USB port.

There are connectors for a TV antenna, FM antenna, S-video in, composite video in, audio in and audio out. A full function remote control is also included. It supports USB 1.1 on a Pentium computer (166MMX min.) using Windows 98SE/Me/2000/XP.

Recommended retail is $179.00.

Contact:
Microgram Computers
PO Box 8202, Tumbi Umbi NSW 2261
Tel: (02) 4389 8444
website: www.mgram.com.au

Who said the floppy is dead?

Many PCs these days do not have floppy disk drives. That's fine until you need to read a floppy! Proving that the 1.44Mb/1.4Mb formats are not yet dead, Targus Australia has launched a new "Slimline" external floppy drive that powers up from the USB port.

This neat little drive (14 x 10.4 x 1.8cm) is completely plug'n'play. The first time it is connected, the notebook recognises the device and treats it just the same as a built-in.

The easy hot-plug installation means it can be connected and disconnected while the notebook/PC is in use and the simple, one cable USB connection means no tangled wires or clumsy 'power bricks'.

With an expected retail price of $109.95, the Slimline can read and write to 3.5-in floppy disks including 720K/1.44Mb Windows (2000, Me & XP) and 1.4Mb Macintosh formats. It carries a full 12-month warranty.

Contact:
Targus Australia Pty Ltd
Tel: (02) 9807 1222
website: www.targus.com.au

Tech-Rentals has R&S FHS3 Handheld Spectrum Analyzer

Tech-Rentals has recently acquired a number of Rohde & Schwarz FSH3 handheld spectrum analyzers; for short or long term rental or purchase.

With small dimensions and a large display, it has an upper frequency limit of 3GHz and numerous measurement functions. It has been specifically designed for mobile applications, including areas of mobile communication such as installation, maintenance, servicing and field-strength measurements, as well as use in labs and universities or by electronics hobbyists.

The integrated Windows software provides relevant documentation allowing the user to track changes in the case of recurring measurements. The measurement results can be stored in the common graphics formats, as text files or in Excel format, complete with date and time and all settings.

Contact:
Tech-Rentals
Tel: 1800 632 652
website: www.techrentals.com.au

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How many times have you wanted to access a company's website but cannot remember their site name?

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BitScope Designs
Contact: sales@bitscope.com
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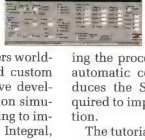
Free simulator program, tutorial

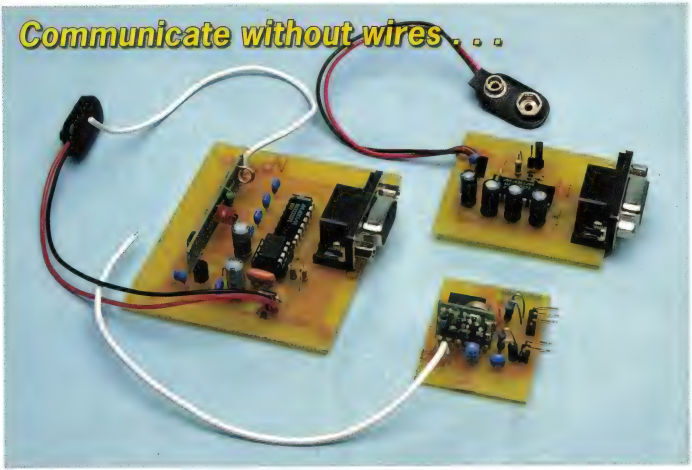
SPLat Controls is an Aus-lian manufacturer of em-ded programmable con-rs who supply OEM users world-with off the shelf and custom l solutions. SPLat have devel- tutorial and companion simu- ogram for users wishing to im- PID (Proportional, Integral, e) control functions.



The program is called PIDassist and simulates a controller and a target process. It can also be used as a data acquisition tool for characterising the process and also includes an automatic code generator that produces the SPLat program code required to implement the control function.

The tutorial is located in the online SPLat Knowledge Base and contains a thorough but non-mathematical treatment of the theory of PID controlnent of an engineering course in Universities or TAFEs. To access the tutorial and download a free copy of PIDassist, go to the SPLat website at **splatco.com.au\splat\pidassist1.htm**. **SC**

Contact:
SPLat Controls
2/12 Peninsular Bvde, Seaford Vic 3198
Tel: (02) 9878 5544 **Fax:** (02) 9878 6366
website: www.splatco.com.au



Smart radio modem for microcontrollers

This cheap and simple radio modem will enable your PICAXE, Stamp or other micro to communicate without wires!

By NENAD STOJADINOVIC

LOW COST, simple construction and easy interfacing makes this project ideal for a whole range of low-speed wireless data applications. Remote control and sensing are two obvious uses and there are undoubtedly many more. Even if you're just learning about microcontrollers, you'll be able to get two PICAXEs talking in no time!

The seeds of this project were sown when I got a call from Mr Vineyard, whose grapes kept freezing during the depths of winter. He said he needed a system that would turn on a misting water spray over the vines when the temperature dropped below a certain level. Apparently, Jack Frost would then freeze the water rather than the grapes. This seemed a bit dubious but I was assured that this is a well-known method of frost damage control.

The only complicating factor wa that the temperature sensors need to be amongst the vines which v up to half a kilometre away fro shed that housed the water valves. Given half a dozen the amount of wiring n clearly impractical. And was very keen to have readout in his home an eye on things.

Going wirele

Wireless ne ous choice fo ler-based te

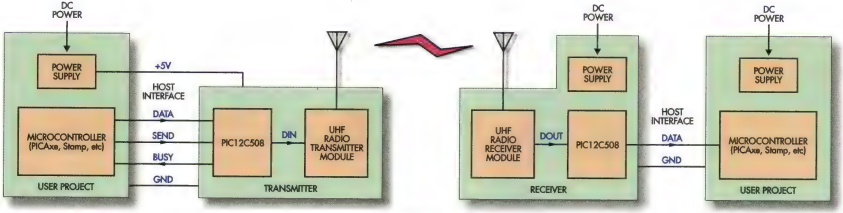


Fig.1: a block diagram of the radio modem, showing how two microcontrollers can be linked together.

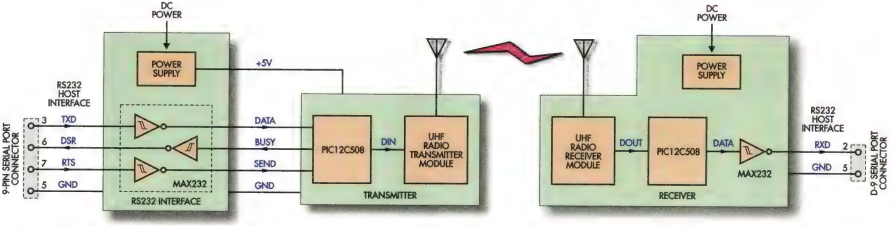


Fig.2: one end of the radio link can also be connected to a PC (or any computer with an RS232 port). As shown here, the receiver includes an RS232 interface on-board, whereas the transmitter requires an add-on interface.

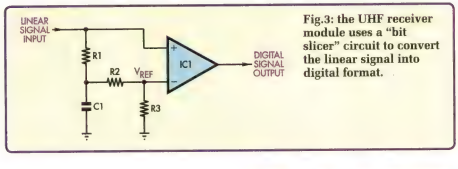


Fig.3: the UHF receiver module uses a "bit slicer" circuit to convert the linear signal into digital format.

strategically amongst the vines could transmit their readings back to a central computer, which would then control the pumps.

Since commercial wireless networking gear was too expensive for this application, the alternative was to design the wireless network from the ground up, with the aid of prebuilt UHF radio modules. These miniature modules operate in the 433.05 - 434.79MHz LIPD band and do not require a license for operation at up to 25mW of output power.

The advertising blurbs suggest that it's simply a matter of pumping serial data into the transmitter module and recovering it at the receiver ("data in - radio out"). Discovering that this was anything but true is what people ruefully refer to as a "learning experience". As it turns out, the data must be "massaged" (encoded, decoded, error checked, etc) at either end of the link to achieve reliable transfer across the airwaves. This was achieved with the aid of Microchip's PIC microcontrollers and many hours of programming. The fruits of these labours are presented here.

Main Features

- Point-to-point, one-way wireless data link
- Error-checked data transfer
- Low cost & easy to build
- 1200 bps serial interface speed
- 465 bps end-to-end speed
- 150-200m range in built-up areas

Project overview

The radio modem consists of a transmitter and receiver pair. The designs use pre-built "Laipac" brand 433.92MHz UHF modules, with PIC12C508 microcontrollers handling the "smarts".

Both transmitter and receiver include a TTL-level (0-5V) 1200 bps (bits per second) serial interface for data transfer. This makes it very easy to hook them up to your Stamp, PICAXE, or other micro (see Fig.1).

In many cases (such as the vineyard application above), one end of the link will need to be connected to a PC (Fig.2). The receiver board includes an RS232 interface for this purpose.

As it's usually the remote part of the link, the transmitter doesn't include an on-board RS232 interface. This saves space and reduces power consumption. Where required, it can be mounted on an (optional) RS232 interface board which also supplies power.

The receiver and RS232 interface can be powered from either a 9V battery or DC plugpack. When used without the RS232 interface, the transmitter must be provided with a +5V supply. This is usually available from the sensor or associated circuitry.

Serial data

Most of our readers will already be familiar with the basics of asynchronous serial data transfer. Those new to the subject will find lots of useful information on the Internet. Two informative sources can be found at:

(1). www.lvr.com/serport.htm
(2). www.beyondlogic.org/serial/serial.htm

The word "serial" simply refers to the fact that data is transferred from sender to receiver a single bit at a time. At a minimum, this requires only one complete circuit (two wires) between the sender and receiver.

With wires and logic signalling levels, it's all pretty straightforward. But how does it work over the airwaves?

UHF radio modules

The radio modules used in this project transmit data by simply switching the carrier signal on and off. The terms "On-Off Keying" (OOK) and "amplitude modulation" (AM) are used interchangeably to describe this method of transmission.

The transmitter module consists of a SAW-stabilised RF oscillator tuned to 433.92MHz. When a logic '0' (0V) is applied to the data input (DIN) pin, the oscillator is off and when logic '1' (+5V) is applied, the oscillator is on. An antenna coupled to the circuit radiates the carrier signal into the ether.

Things get a bit more complicated at the receiver side. Unfortunately, the manufacturer's data sheets don't reveal

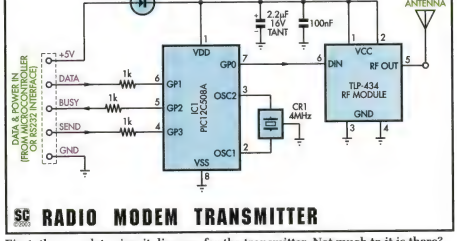


Fig.4: the complete circuit diagram for the transmitter. Not much to it is there? An 8-pin PIC microcontroller (IC1) receives serial data from the host (PICAXE, Stamp, etc) and transmits it over the airwaves using a UHF transmitter module.

much about its operation. Of course, we do know that it amplifies and rectifies the narrow-band 433.92MHz (±1.5kHz) signal picked up by the antenna, with the result appearing on the Linear Output (L_{OUT}) pin.

Data slicing

A digital version of the signal also appears on the Digital Output (D_{OUT}) pin. Conversion between analog (linear) and digital is performed with a "bit slicer" circuit. As the name suggests, the bit slicer looks at the incoming signal and decides whether it should be a logic '0' or logic '1', "slicing" it up accordingly.

This is achieved with a circuit similar to that shown in Fig.3. IC1 is configured as a comparator and once the capacitor is charged up, a signal peak at the input will result in a high at D_{OUT} while a signal minimum will result in a low.

The frequency of '1's (transmitter on) and '0's (transmitter off) in the data stream determine the accuracy of the slicer. If the time between '1's is too long, the capacitor voltage sags and '1's will be detected as '0's instead. Conversely, if the data stream contains

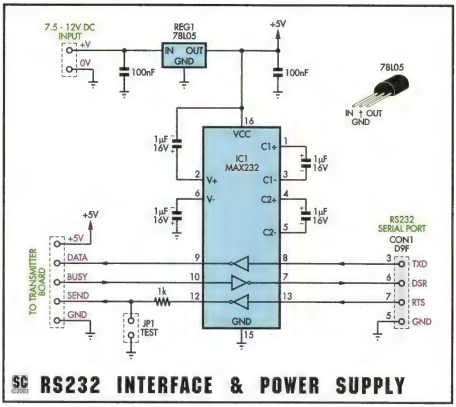
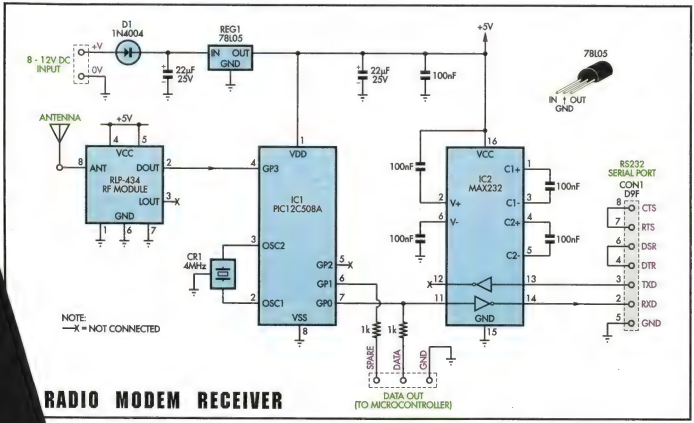


Fig.5: this add-on interface connects the transmitter to an RS232-compatible serial port. The MAX232 chip (IC1) handles the RS232 (±10V) to TTL (0-5V) level conversion, while 3-terminal regulator REG1 also powers the transmitter board.



...e receiver circuit is almost a mirror image of the transmitter. PIC micro IC1 receives data from the UHF receiver ...and after decoding and error checking, passes it on to the host via the DATA output. Unlike the transmitter, an ...terface (IC2) is included on-board.

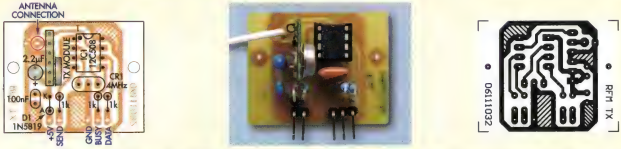


Fig.7: follow this diagram when assembling the transmitter. If you've opted for a more elaborate antenna (instead of the single length of wire), the coax shield can be soldered to the ground pad right next to the antenna connection point.

too many consecutive '1's, a '0' will go undetected.

Transmission speed also affects the average voltage on the capacitor. Circuit time constant is optimised for a particular "baseboard" data rate, which for these modules is specified as 3000 bps.

As you can see, the ideal situation exists when the transmitter is fed with an alternate stream of '1's and '0's at the prescribed data rate. In fact, data transmission must begin with a preamble of alternating 1's and 0's of sufficient length to "initialise" the data slicer at the receiver end.

Of course, during "normal" transmission, data can consist of any combination of '1's and '0's. This is easily accommodated by encoding the data before transmission.

Manchester encoding

A number of encoding techniques can be employed to ensure that the data stream contains a balance of '1's and '0's.

This project uses "50% Manchester" encoding, which simply involves sending every bit along with its complement. Thus '0' becomes '01' and '1' becomes '10'. It is simple and robust but does take twice the time to send each byte. However, this is not of particular concern for our "low-speed" link.

Error detection

With all the potential for lost or corrupted data over a radio link, some kind of error detection system is mandatory. Along with data encoding, error detection is another of the main functions of the PIC microcontrollers in the transmitter and receiver pair.

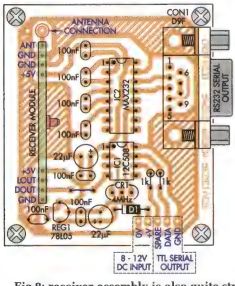
The PIC micro in the transmitter sends data in blocks or "packets". Before transmission, all data bytes in a packet are passed through a polynomial generator, with the result being an 8-bit number called a "Cyclic Redundancy Check" (CRC). This byte is appended to the end of a packet before transmission.

On the receiver side, incoming data is passed through the same polynomial generation algorithm and the result is compared to the received CRC byte. If they match, the data is deemed good. Otherwise, it is assumed bad and the entire packet discarded.

If you're interested in the algorithm and microcontroller code required to generate CRCs, then check out Microchip's application note AN730, entitled "CRC Generating and Checking". It can be downloaded from **www.microchip.com**.

Bytes & packets

As mentioned above, data received from the "host" (your PICAXE, Stamp,



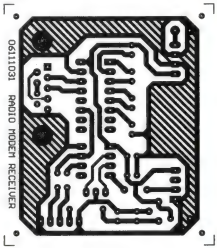


Fig.8: receiver assembly is also quite straightforward. The UHF receiver module must be oriented with its inductors (coils) facing the two ICs. The "SPARE" signal line is not used and should be left unconnected.

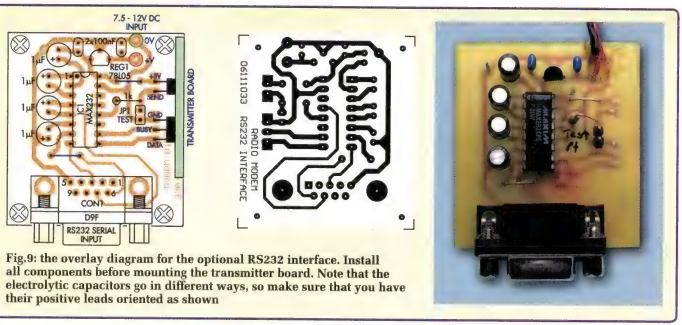


Fig.9: the overlay diagram for the optional RS232 interface. Install all components before mounting the transmitter board. Note that the electrolytic capacitors go in different ways, so make sure that you have their positive leads oriented as shown

PC, etc) is assembled into packets before transmission. Each packet is preceded with a preamble, two "authorisation" bytes (FF 00) and a length byte to indicate the number of data bytes to follow. Data length may be from 1-16 bytes, with a CRC byte appended to the end.

Of course, the receiver returns only the data part of the transmission to its host; the other bytes are strictly for housekeeping. This means that apart from a certain amount of latency, the radio modem link looks just like a piece of wire between the sender and receiver!

So far, we've only described the radio side of the link. Let's now look at how you connect your PICAXE, Stamp or whatever to the transmitter and receiver.

Transmitter hook-up

Your microcontroller project interfaces to the transmitter via a 3 or 4-wire interface (see Fig.1). For a basic setup, you need connect only the DATA, SEND and GND lines.

Serial data must be sent on the DATA line at 1,200 bps using the standard format of 8 data bits, no parity and 1 stop bit. The SEND line is used for handshaking and in the idle state must be held high (+5V).

To transmit data, send 1-16 bytes and then bring the SEND line low (0V). Data transmission begins immediately and after an appropriate delay (see the "Radio-Modem Performance" panel), the SEND line can be brought high again and the transmitter is ready to accept more data.

The PICAXE microcontroller program to transmit a single character at a time might look something like that shown in Listing 1.

Listing 1

```
symbol  SEND = 1                        'transmitter SEND line on pin 1
symbol  TX_DATA = 2                     'transmitter DATA line on pin 2
begin:  high    SEND                    'raise the SEND line
        pause   1                       '1ms delay
        serout  TX_DATA,T1200,("A")     'load the ASCII character "A"
        low     SEND                    'lower the pin to send the data
        pause   500                     'wait 0.5 sec while the data goes
        goto    begin                   'loop to repeat forever
```

For maximum transmission speed, the BUSY line can be connected as well. This line is an output from the transmitter and indicates its status. When BUSY is high, the transmitter is sending data, and when low, it's ready to accept the next packet of data. Listing 2 shows a simple example.

Note that attempting to load more than the maximum of 16 bytes at a time will result in BUSY going high and the additional bytes going into the bit bucket.

Receiver hook-up

The receiver interface is even simpler and requires only a 2-wire connection. Again, a fragment of PICAXE

Listing 2

```
symbol  SEND = 1                        'transmitter SEND on pin 1
symbol  TX_DATA = 2                     'transmitter DATA on pin 2
symbol  BUSY = 3                        'transmitter BUSY on pin 3
begin:  high    SEND                    'raise the SEND line
        pause   1                       '1ms delay
        serout  TX_DATA,T1200,("Hello") 'load the ASCII string "Hello"
        low     SEND                    'lower the pin to send the data
        pause   1                       '1ms delay
waitrdy:
        if BUSY = 1 then waitrdy        'loop until not busy (data sent)
        goto    begin                   'repeat forever
```

Radio Modem – Performance

Range: maximum output power with a 5V supply is listed as 25mW (14dBm) into a 50Ω antenna. This provides a range of 150 - 200 metres in the suburbs and rather more over open terrain. Maximum range is heavily dependent on antenna efficiency and environmental conditions.

Speed: data is transferred between the transmitter/receiver and the connected device (PC, PICAXE, etc) at a rate of 1200 bps. However, due to the overheads involved in the radio transmission, actual throughput is slightly less than half that speed.

Calculated on a maximum payload of 16 bytes per transmission, the radio link speed is equivalent to about 465 bps. That's about 343ms per transmission, plus the time taken to load and unload the data at either end (about 8.33ms per byte).

Power consumption: with a 9V supply, the receiver consumes about 16mA. More than 10mA of this is used by the MAX232, so for battery-powered receivers, don't install this chip if it's not needed.

When idle, the transmitter requires less than 1mA. During transmission, this peaks at about 6mA. When plugged into the RS232 board, total consumption increases to 12mA at idle and about 17mA (peak) when transmitting.

code illustrates how to receive a byte – see Listing 3.

As you can see from this listing, it's simply a matter of listening on the DATA line for the incoming serial data.

PC Connection

One end of the link can also be connected to a PC or other computer system with an RS232-compatible serial port (see Fig.2). The receiver board includes an RS232 interface, so it's a simple plug-n-play proposition.

Alternatively, for remote control applications, the transmitter end can have the RS232 connection. A simple add-on RS232 interface board (is required for the hook-up (see Fig.6 and the photos).

A PC connected to the receiver board can display and/or capture incoming data with a simple serial terminal program (see the testing procedure below). If the data is in ASCII format, Windows "HyperTerminal" will suffice. However, if you want to see the "raw" binary data, then you'll need a program like "RealTerm" instead. RealTerm is available free from **realterm.sourceforge.net**.

To send data from a PC connected to the transmitter, you need more than a simple terminal program. Your application must take control of the SEND line (RTS), and optionally read the status of the BUSY line (DSR).

Note: the radio modem is not intended for PC to PC data transfers. Attempting to move "PC-sized" amounts of data across a 465 bps link would be pointless.

Transmitter assembly

With only nine parts on the board, you'll have the transmitter assembled in no time at all. Fig.7 shows the component placement.

The three 1kΩ resistors must be mounted vertically rather than horizontally and note the orientation of the 2.2µF capacitor and microcontroller (IC1). In addition, make sure that you have the transmitter module in the right way around – the SAW resonator (in the round metal can) must face towards IC1.

Receiver assembly

Install the single wire link first, using 0.7mm tinned copper wire. All components can then be installed in order of height (see Fig.8).

Again, take care with the orientation of the polarised components, these being diode D1, the 22µF capacitors and the ICs. The receiver module goes in with its coils facing toward the ICs (see photos).

If don't intend connecting the receiver to a PC, you can leave out the MAX232 receiver/driver (IC2). This will save power in a battery-powered setup. However, you may prefer to socket the chip and remove it later, as the test procedure (below) requires a PC connection.

RS232 interface assembly

As before, install the two wire links first, then all components in order of height. Take particular care with the orientation of the four 1µF capacitors, as they go in different ways around on the PC board.

The transmitter board mounts vertically near one edge of this board via 90° header pins. Install the 2-way and 3-way SIL header pins on the transmitter board first and then fit this assembly to the RS232 interface board.

Before soldering into place, check that the edge of the transmitter PC board contacts the RS232 PC board and that the whole arrangement is sitting "square".

Antenna

For testing purposes and many real-world applications, the antenna can be as simple as a 165mm length of light-duty hook-up wire. Strip and tin one end of the wire and solder to the transmitter's antenna connection point. Repeat for the receiver board (see Figs.7 & 8).

For best results, the antenna wires should be kept clear of large metal objects and human bodies!

Testing

Both the receiver and RS232 interface boards can be powered from a 9V battery or 9V DC plugpack. The battery clip leads (or flying leads from a panel-mount DC socket) can be soldered directly to the '+V' and '0V' pads.

Note: 12V DC unregulated plugpacks are not suitable for this project due to their excessively high output voltages at light loads.

If you're not using the RS232 board, connect a regulated 5V supply to the transmitter's '+5V' and 'GND' pads.

Next, connect the receiver to a free

Listing 3

```
Symbol  RX_DATA = 2                    'receiver DATA on pin 2
serin  RX_DATA,T1200,B2                'wait for a byte & store it in variable B2
```

Where To Get The Parts

Kits of parts for this project are available from the author. Kits include the PC board and all on-board components (battery, plugpack, enclosure & antenna are not supplied). At time of writing, prices are as follows:

Transmitter	$25
Receiver	$40
Transmitter & Receiver pair	$60
RS232 Interface	$25

Programmed PICs can also be purchased separately:

PIC12C508A for Transmitter (including 4MHz resonator)	$15
PIC12C508A for Receiver (including 4MHz resonator)	$15

If you're interested in a "rubber duck" or other specialised antenna, write and ask for a current price list. All prices include postage within Australia. To order, write or email the author at:

Nenad Stojadinovic, PO Box 320, Woden, ACT 2606.

email: **vladimir@u030.aone.net.au**

The Laipac UHF transmitter & receiver modules are also available from Commlinx Solutions, on-line at **www.commlinx.com.au**

serial port on your PC using a standard 9-way "pin-to-pin" cable (not a "null modem" type). To be able to "see" the incoming data, launch your favourite serial terminal application. HyperTerminal (supplied with Windows) will do the job. Set the terminal's communication parameters to match the chosen COM port, with a data rate of 1200 bps, 8 data bits, 1 stop bit and no parity.

Right, we're all set. Make sure that transmitter power is off and place a jumper shunt across the "TEST" pins (JP1). Now power up the transmitter and you should see the characters "0123456789:;<=>?" appear in the terminal window.

A built-in test routine transmits this string of characters continuously when the SEND line is held low (0V) at power-up. This, of course, is the purpose of the "TEST" jumper.

Fault-finding

No go? First, check the supply rails. To do this, use your multimeter to measure between pins 1 & 8 of IC1 on both the transmitter and receiver boards. On the receiver, expect close to 5.0V, whereas on the transmitter, your reading should be about 4.7V.

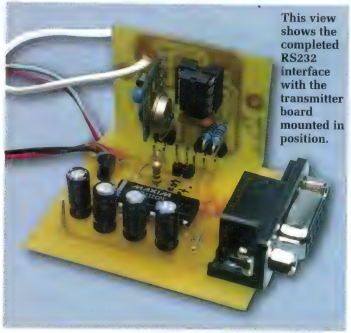
Next, use a logic probe or oscilloscope to monitor the signal on pin 7 of the transmitter's micro (IC1). With the jumper shunt (JP1) installed at power-up, there should a burst of pulses each time the 16-character test string is transmitted.

If that checks OK, then it's over to the receiver side. Examine pin 4 of the receiver's micro (IC1). Normally, background noise picked up by the UHF receiver module appears on this pin as random "garbage". However, you should see a distinctive change in the pattern whenever the test string is received.

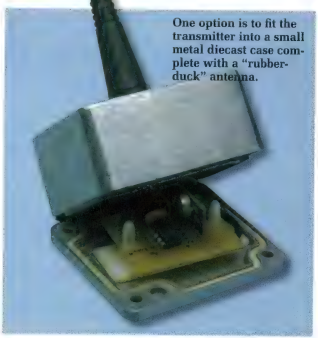
Assuming that you see signs of activity, then measure at the micro's serial data output (pin 7). Again, brief bursts of pulses should appear here if the test string is received successfully.

The last link

The last link in the chain is the MAX232 (IC2) on the receiver. As shown on the circuit diagram (Fig.6), serial data from the micro (pin 7) is applied to the MAX232 on pin 11. Therefore, it should appear on pin 14 after conversion to the ±10V (nominal) RS232 signal levels. This pin should sit near -8V when idle and pulse to about +9V when sending the test data.



This view shows the completed RS232 interface with the transmitter board mounted in position.



One option is to fit the transmitter into a small metal diecast case complete with a "rubber-duck" antenna.

Parts List

Receiver
1 PC board coded 06111031, 63mm x 55mm
1 Laipac RLP-434 transmitter module
1 PIC12C508A (programmed) (IC1)
1 MAX232 RS232 receiver/driver (IC2)
1 78L05 +5V regulator (REG1)
1 1N4004 diode (D1)
1 4MHz 3-pin ceramic resonator (CR1)
1 D9 female connector, 90° PC-mount (CON1)
1 9V battery & battery clip -OR-
1 9V DC 150mA plugpack & panel-mount DC socket to suit

Capacitors
2 22µF 25V PC electrolytic
7 100nF 50V monolithic

Resistors (0.25W, 1%)
2 1kΩ

Transmitter
1 PC board coded 06111032, 37mm x 29mm
1 Laipac TLP-434 transmitter module
1 PIC12C508A (programmed) (IC1)
1 1N5819 Schottky diode (D1)
1 4MHz 3-pin ceramic resonator (CR1)

Capacitors
1 2.2µF 16V tantalum
1 100nF 50V monolithic

Resistors (0.25W, 1%)
3 1kΩ

RS232 Interface (optional for transmitter, see text)
1 PC board coded 06111033, 51mm x 46mm
1 MAX232 RS232 receiver/driver (IC1)
1 78L05 +5V regulator (REG1)
1 D9 female connector, 90° PC-mount (CON1)
1 3-way 2.54mm 90° SIL header
1 2-way 2.54mm 90° SIL header
1 2-way 2.54mm SIL header (JP1)
1 jumper shunt (JP1)
1 9V battery & battery clip -OR-
1 9V DC 150mA plugpack & panel-mount DC socket to suit

Capacitors
4 1µF 16V PC electrolytic
2 100nF 50V monolithic

Resistors (0.25W, 1%)
1 1kΩ

If you've successfully traced the test data from start to finish, then the problem must be related to your computer! Double-check the terminal program settings and the cable connection between the unit and the PC.

A good vintage, indeed

What of the "radio thermometer" project? Well, I built it into one of those cheap solar-powered LED garden lights. Using 'sleep' mode on the micro, the device now sends temperature and humidity readings to the water control unit every minute or so and is working very nicely after six months of totally unattended operation!

More reading

Technical data on the RLP-434 & TLP-434 UHF modules used in this project can be downloaded from the Laipac Technology web site at **www.laipac.com**

For details on government regulations regarding LIPD radio communications devices, visit the Australian Communications Authority web site at **www.aca.gov.au/aca_home/legislation/radcomm/class_licences/lipd.htm**

A high-performance commercial radio modem was reviewed in SILICON CHIP, February 2003. Details on the WM232-UHF modem featured in the review can be obtained from **www.radiotelemetry.net.** SC

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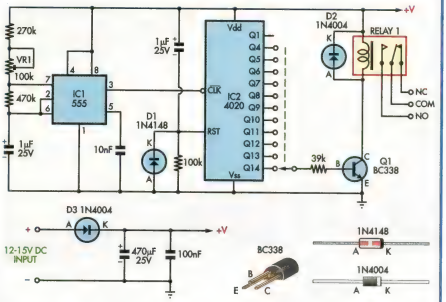
CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.



Making the Flexitimer cycle on and off

The Flexitimer published in the March 1991 issue of "Electronics Australia" is still a popular project but it has the drawback that it is "once only" timer. Once it has timed out, it is effectively disabled.

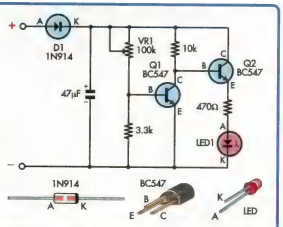
We have had many requests asking how it can be made to cycle on and off. This can easily done, as shown with this modified circuit. This makes it cycle on and off with a 50% duty cycle, for as long as power is applied. So for example, if it is set for a period of 8192 seconds, it will be off for 8192s, on for 8192s and so on.

The modification involves cutting the track connection between pin 4 (reset) of IC1 to the collector of Q1 and tying it to pin 8 (+V).

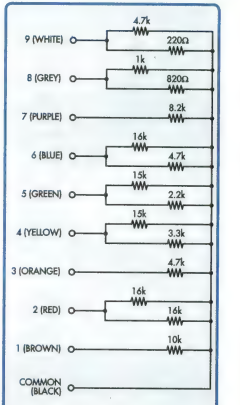
Silicon Chip.

Low battery indicator

This simple circuit lights LED1 when the battery voltage drops below the setting set by trimpot VR1. In effect, VR1 and associated resistors bias Q1 on which holds Q2 and the LED off. When the voltage drops below the set value, Q1 turns off, allowing Q2 to turn on and light the LED. The circuit is suitable for nominal battery voltages up to 12V.



I. Ross,
Springwood, Qld. ($30)



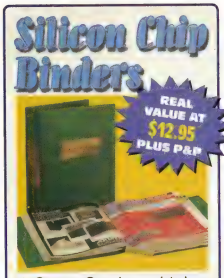
Simple 9-way cable identifier

Here is a simple way of identifying multiple cables (with the aid of a multimeter). The circuit consists of a series of resistors, selected so that they give readings that coincide with the 1-9 numerals on the 10V scale on a multimeter switched to the Ohms x 100 range.

In use, a common wire needs to be chosen and this is usually the shield wire. The resistors go to one end of the cables to be identified, while the multimeter is used at the other end to check the values and identify each lead.

Up to nine cables can be identified at a time. If a mistake is made in choosing the common lead, the readings will all be wide of the 1-9 numerals on the 10V scale, thus making the mistake obvious.

J. Begg, Heidelberg, Vic. ($20)



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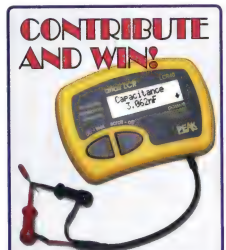
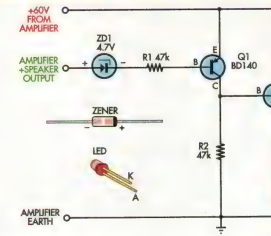


As you can see, we pay good money for each of the "Circuit Notebook" contributions published in SILICON CHIP. But now there's an even better reason to send in your circuit idea: each month, the best contribution published will win a superb Peak Atlas LCR Meter valued at $195.00.

So don't keep that brilliant circuit secret any more: send it to SILICON CHIP and you could be a winner!



Clipping indicator for audio amplifiers

A clipping indicator is a useful accessory on any audio amplifier. It indicates when the amplifier has reached its limit and is clipping the peaks of the audio signal.

In practice, quite a lot of clipping can occur before you can hear it. So why is it necessary to know when an amplifier is clipping if you can't notice it? The answer is that clipping "squares up" the waveform and square waves contain lots of higher-frequency harmonics which can easily damage the tweeters in loudspeaker systems.

This circuit is a true clipping indicator as opposed to the level indicators that are commonly used in preamplifier stages. The problem with level indicators is that an amplifier's maximum output power is not constant. That's because the amplifier's supply rails are not regulated and so the maximum power available at any given instant varies, depending on the applied signal.

The circuit is quite simple and is based on two BD140 PNP transistors and zener diode ZD1. During normal operation, Q1 is turned on via ZD1 and R1. As a result, Q2 is held off (since its base is pulled high) and so LED1 is also off.

However, if the output signal subsequently rises to within 4.7V of the positive supply rail, Q1 turns off since it no longer has any forward bias on its base. As a result Q2's base is now pulled low via R2 and so Q2 turns on and lights LED1. (Note: the 0.6V drop across Q1's base/emitter is ignored here because ZD1 conducts before its rated voltage due to the very low current involved).

Why choose 4.7V below the power rail as the turn-on point? The reason is that, due to the drive limitations and the nature of emitter followers, they can be expected to have at least 4V across them when they saturate (ie, clip).

ZD1 can be increased to a 5V or 6.2V type if the circuit is to be used with a monster amplifier.

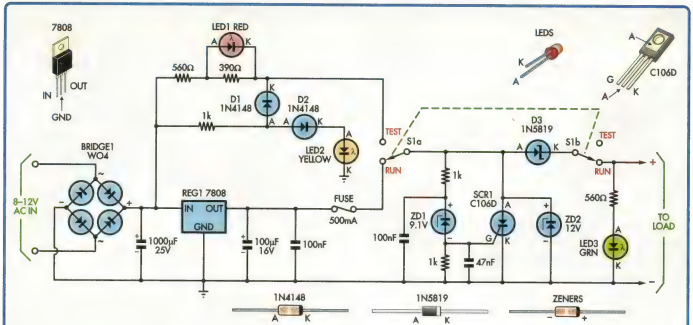
The value of R3 should be customised according to the amplifier's supply rail, so that LED1 operates with the correct brightness. To do that, first measure the amplifier's positive supply voltage, then use Ohms Law (R = V/I) to calculate the value of R3 for a current of about 20mA.

As it stands, this circuit can only be used to monitor the positive-going half-cycles of the audio waveform. If you want to monitor the negative half-cycles as well, you will have to build a second circuit with the following changes: (1) reverse both LED1 and ZD1; and (2) use BD139 (NPN) transistors for Q1 & Q2.

Note that, in both cases, you should use the earth inside the amplifier, as the speaker negative may not be earth (such as in a bridged output).

Philip Chugg,
Launceston, Tas.

Philip Chugg is this month's winner of the Peak Atlas LCR Meter



8V DC supply with overvoltage protection

This 8V DC power supply was designed for use with an expensive piece of electronic equipment. It features full over-voltage protection as a precaution against regulator failure, either in the supply itself or inside the equipment it is powering.

The circuit uses a conventional full-wave rectifier, followed by a 3-terminal voltage regulator (REG1) with appropriate filtering. When power is applied and switch S1 is in the "Run" position, REG1's output is fed to the load via a 500mA fuse and Schottky diode D3. This also lights LED2 (yellow) and LED3 (green), which respectively indicate the presence of the unregulated and regulated voltages.

D3 is there to protect the circuit against external voltage sources (eg, charged capacitors).

A "crowbar" circuit comprising ZD1 and SCR1 provides the over-voltage protection. It works like this: if a fault develops (eg, REG1 short circuit) which causes the output voltage to rise above 9.1V, ZD1 turns on and applies a voltage to the gate of SCR1. If the voltage then continues to rise, SCR1 turns on (at about 10V) and "blows" the fuse.

Zener diode ZD2 provides emergency over-voltage protection in case the "crowbar" circuit develops a fault.

Switch S1 is provided so the operator can occasionally test the "crowbar" function. When S1 is switched to the "Test" position, the load is disconnected by S1b and the unregulated supply voltage is applied by S1a to the "crowbar" circuit, thus causing it to trigger. When this happens, LEDs 2 & 3 (green and yellow) extinguish and LED1 (red) lights to indicate that the SCR has triggered.

The SCR turns off again when S1 is switched back to the "Run" position.

L. Cox,
Forest Hill, Qld. (45)

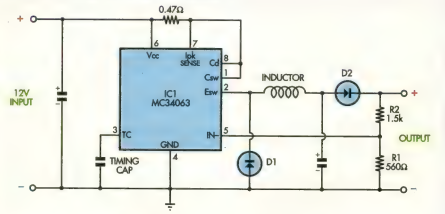
Cheap switchmode DC-DC converter

This circuit is based on mobile phone chargers available from bargain stores such as "Silly Sollys" for about $4.99.

These chargers are based on the Motorola MC34063 switchmode IC. By changing the values of the feedback resistors (R1 & R2), the output voltage can be varied over a wide range.

Just modify R1 and R2 according to the formula:

Vout = 1.25 (1+R2/R1).



The values shown give an output of 3V.

Timo Mahoney,
Chillagoe, Qld. ($30)

BIG BROTHER IS WATCHING YOU. . .

(Picaxe's big brother, that is)

OK, Picaxe enthusiasts – you've diligently followed our "08" articles and can rightly claim your Picaxe "drivers licence". Time to hit the highway, maybe?

by Stan Swan

As hinted during our earlier articles, the Picaxe range includes seven big brothers, grouped into 18, 28 and even 40-pin families. Although the baby "08" remains supreme for simple control circuits, it's rather like using a two-door hatchback for a cross country workout.

Consider the 18s as perhaps akin to 4WDs, 28s as Rally cars, while 40s. mmm – well you get the idea! The 40X is so long in fact that it looks like a toy aircraft carrier!

These larger devices, although featuring powerful further commands, still obey the key 35 "08" instructions, so all you've learnt so far can be immediately put to use – but it's obviously a waste to spend much more to just flash a few LEDs with them!

Although this month's coverage relates to the 18A, we've also shown a summary of the family overall (including the recently-released fire-breathing 18X). All enjoy the usual wide supply voltages (3-5.5V), 4MHz clock and direct ~20mA output drive but larger versions have dedicated Input or Output pins rather than the versatile I/Os of the "08".

Note that the basic 18 and 28 Picaxes, inferior to the "A" and "X" versions, are obsolete and no longer marketed. Incidentally, no "A" or "X" updates are planned for the "08" series.

Since Picaxes of course are PIC based, it's worth comparing the pin compatible 18-pin models with the ubiquitous PIC16F84 – now itself obsolete as replaced by the cheaper and more powerful 16F627 with an internal oscillator as well.

The enhanced PIC16F627 (the 16F819 – only released by Micro-Chip in January 2003), is the PIC that the "18A" (bootstrapped by Rev. Ed of course) is based on.

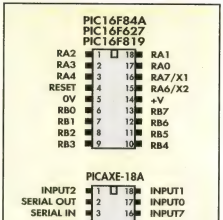
Picaxe-18A features:

New features include (with associated commands in italics) –

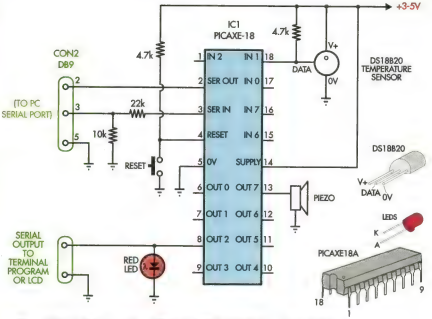
1) Accurate digital temperature sensor interface for direct Celsius readings using the Dallas Semiconductor (Maxim) "1 wire bus" DS18B20 I.C. – ***readtemp***
2) Direct PC keyboard interface allowing inputs 6 and 7 interface – ***kevin, keyled***
3) Interrupts to immediately respond

Name (Pins)	Mem lines	I/O	Out pins	In-puts	ADC (Low)	Data mem.	Polled Interrupt	PIC type	Cost (A$) (approx)
08	40	5	1-4	1-4	1L	128-prog	-	12F629/675	$4
18	40	13	8	5	3L	128-prog	-	16F627	-
18A	80	13	8	5	3	256	Yes	16F819	$10
18X	600	14	9	5	3	256+I2C	Yes	16F88	~$14
28	80	20	8	8	4	64+256	-	16F872	-
28A	80	20	8	8	4	64+256	Yes	16F872	$15
28X	600	21	9-17	0-12	0-4	128+I2C	Yes	16F873A	$20
40X	600	32	9-17	8-20	3-7	128+I2C	Yes	16F874	$28

Here's a summary of the currently-available Picaxe chips which also gives their various parameters, allowing you to pick (no pun intended!) the right one for you. The 18X is the new kid on the block, released only last month.



Here's the pinout comparison between the PICAXE-18A and the PIC 16F family, on which it is based.



PICAXE-18A TEMPERATURE SENSING

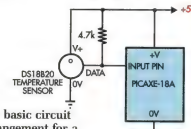
to input changes while otherwise busy – ***setint***

4) Infrared detection to enable remote control from a TV style handset – ***infrain***
5) Accurate clock chip interface for precise time keeping – ***readowclk, resetowclk***
6) iButton interface to allow electronic keys to be used within projects – ***readowsn***
7) Servo control to directly drive up to eight radio controlled servos – ***servo***

Additionally the ***readadc*** command, previously only a low resolution "08" feature, now allows high resolution 256-step ADC inputs on pins 0, 1 and 2. Phew! There's enough here for such a swag of circuits that you'll be busy for months.

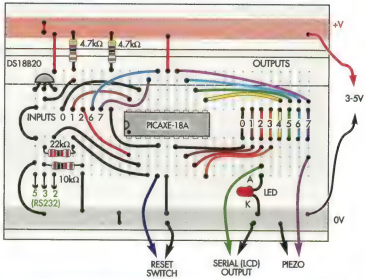
And the new "18X" introduces a further half-dozen features (I²C memory enhancement especially) that'll keep us happy until Christmas (note we didn't say *which* Christmas!).

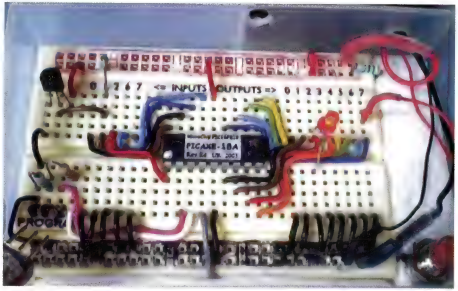
We'll work up designs each month



The basic circuit arrangement for a PICAXE-18A and DS18B20 temperature sensor. Getting data in is as simple as connecting them together!

Circuit diagram and protoboard layout for this month's PICAXE fun. Again, there are some differences between the photo below and this layout (redrawn for clarity) but electrically they are identical. The normal "08" programming cable is still used.





DATADS18.BAS

(Also downloadable from: www.picaxe.orcon.net.nz/datads18.bas)

```
'PICAXE-18A TEMP. DATALOGGER for Nov 2003 "Silicon Chip" article.  Ver 1.00   1/9/03
'Use with DS18B20 temp sensor IC etc to Picaxe-18A In 1. Via=> s.t.swan@massey.ac.nz
'DS18B20 reads -10C to +85C to +/- 0.5C,but wider with less accuracy. Supply 3- 5.5V
'N.B.Subzero "bug"-temps <0 C read as ascending from 128. Ex 129 = -1C, 130 = -2C etc
'Possibly address by 2's complement or subtracting value from 128. Thus 128-131= -3
'Program is "hi res" enhancement of lo res datalog8.bas as in Sept.'03 SiChip article
'When "18A" powered up,any prior stored EEPROM values sent as pin 2 serial port data
'-suit display via any terminal program -LCD,BananaCom,F8,StampPlot- or.csv Excel too.
'NB-Gives you 30secs to turn unit OFF before fresh storage begins & thus progressively
'wiping existing values ! For security however this data can't easily be bulk erased
'***BUT CARE - BE PROMPT ! REPROGRAMMING/RELOADING  "18A" TOTALLY WIPES
DATA TOO ****.
'As set up logs direct Celsius temp every 15 secs for ~1 hr. Alter WAIT value to suit?
'A further tempting "18A" enhancement uses DS2415 or DS 1307 clock chip  for improved
'logging times. Both these & DS1820 can now be PICAXE-18A read, but not-sniff- by "08"
'-------------------------------------------------------------------------------
'PICAXE18A has hi-res data values 0-255(via "readadc" command),but also READTEMP for
'direct DS18B20 Celsius readings! Values stored in non program space too (unlike "08")
'"Data compression" scope that'll maybe give 512 values ? 18X + I2C better if pushed
'If power saving needed use SLEEP instead of WAIT ex. 25x2.3secs ~1min delay (+/- 1% )
'Alter to suit.Ex. Sleep 391 =256 x 1/4 hr =64 hrs.Some interpreter o'head/drift noted
'Solderless "PICNIK" breadboard setup pix => www.picaxe.orcon.net.nz/datads18.jpg
'Sample Excel graph resulting (1 hour run)=> www.picaxe.orcon.net.nz/datads18.gif
'Program hosted=> www.picaxe.orcon.net.nz/datads18.bas  & circuit=> ... /picxds18.gif
'-------------------------------------------------------------------------------
'ASCII  INPUTS    3-5V +supply   OUTPUTS                    DS18B20 pinouts
' art   + + + + + + + + + + + + + + + + +                   (top view )
'    |     |
' DS18B20          |          _Serial   _Piezo                * *
' |  |    ————————      |     |                  *   *
' |  0 1 2 6 7 =I PICAXE  I=0 1 2 3 4 5 6 7                    *     *
' |          =I  18A   I=   L                                  *   *
' |__0V        ————————      E                    ————————
'                 |      D                    / / /
' |||             |    | | | | | | | | |     / / /
'Prog.  - - - - - - - - - - - - - - - - -                  0V  I  V+
'input  Common ground for serial,DS18B20,piezo & supply data
'-------------------------------------------------------------------------------
                                  'READ/PLAYBACK ROUTINE
serout 2,n2400,(12,"PICAXE-18A Temp.Datalogger  ")'ASCII values 12=FF(= cls), 44=comma
for b0=0 to 255                   'stored data values readout to terminal or LCD
read b0,b1                        'polls & reads out stored eeprom values ( .csv)
serout  2,n2400,(#b1,44)          'Actual value @ pin 2,then comma for Excel .csv
pulsout 2,500                     'paralled output 2 LED flashes to confirm data
next b0                           'read next stored EEPROM value serial out
serout  2,n2400,(10,13,10)        'Forces fresh line for new data run(10=CR,13=LF)
wait 30                           '30 secs "reading" delay -modify if too short etc
'-------------------------------------------------------------------------------
                                  'WRITE/DATA LOGGING ROUTINE
for b0= 0 to 255                  'begin 256 data readings at time set by SLEEP
sound 7,(75,10)                   'Beep to alert data logging commencing
pulsout 2,500                     'brief flash from pin 2 LED indicates datalogging
readtemp 1,b1                     'direct Celsius reading of DS18B20 temp. returned
serout  2,n2400,(#b1,44)          'Now allows display of data as gathered too !
write b0,b1                       'sequentially write values to EEPROM locations
wait 15                           'Checks every 15 secs (max 65)-alter to suit etc
next b0                           'Gathering automatically stops after 256 samples
'-------------------------------------------------------------------------------
```

Note: the "ASCII art" in the middle of this text listing appears scrambled but when downloaded from the website lists perfectly.

to keep you stimulated, with a style that gives command insights to start followed by applications such as the enhanced data logger this month.

Let's go!

Right – seat belts fastened? When testing any new micro controller it's traditional to first flash a LED.

Flash a LED – that's kids stuff for any Picaxe! Let's do this instead with panache and "get the ice broken" while also measuring temperature.

Digital temperature sensors

For years the only real practical way of measuring temperature in projects was with "hard to calibrate" non-linear NTC thermistors (as used in the September 2003 article).

However, digital temperature sensors, of which the 3-wire Dallas Semiconductor DS18B20 is probably best known, output the exact temperature in degrees Celsius and are now available at much the same price as thermistors.

Initial DS1820s (note the missing "B") were somewhat taller but proved drift-prone and are no longer supported. Incidentally, this "BC547 lookalike" is NOT a transistor.

The Picaxe connection is very straightforward indeed – below is a code snippet that switches our pin 2 LED on and off at exactly 25° Celsius.

Simplicity itself! And of course you want to try this out right away! But how do you house this 18-pinner for testing?

Ideally, it would be with something like the Rev-Ed AXE-30 "18A" Starter Pack (retail A$40), which includes ca-

References and parts suppliers . . .

(also refer to previous months articles)

1. Revolution Education (www.picaxe.com) gave generous permission to reproduce 18A data and graphics.

2. Australian Picaxe agent Micro-Zed (www.picaxe.com.au) supply most Picaxe parts, including the DS18B20 (~A$3).

3. Dallas Semiconductor (recently merged with Maxim) www.maxim-ic.com/1-Wire.cfm

4. Authors's Picaxe resource page www.picaxe.orcon.net.nz – includes program listings

```
main:     readtemp 1,b1          'read temp at pin 1 via DS18B20
          if b1 > 25 then LEDon  'LED on if temp (b1) beyond 25C
          low 2                  'temp <=25 so LED goes/stays off
          goto main              'keep looping and measuring

LEDon:    high 2                 'temp >25 so turn on LED output 2
          goto main              'keep looping and measuring
```

If you just want to experiment without loading the complete code opposite, try this little program chunk.

bles, CDs, battery box, 18A and PC board. It's an elegant, if costly, solution – but fortunately our (cheap!) solderless PICNIK box conveniently allows a 300 hole breadboard swap-out that *just* accommodates an 18A version instead.

Not all I/O lines need be fitted (especially if you are not using them!) and even the reset push button at pin 4 may be surplus but it's suggested the wiring style and colour coding shown is followed to allow versatility for later circuits.

Just in case you hadn't twigged, input and output 0 (zero) are black, 1 are brown, 2 are red, etc, etc . . . Now where have we come across that colour coding before?

Note the more usual "supply above, ground below" rails on this breadboard (the "08" had unusual supply pins). Useful development space remains on the breadboard, which easily accommodates the DS18B20 temperature sensor. This could of course be mounted remotely to measure the temperature of something, rather than the air around it!

Once all hardware is ready, ensure your Picaxe Editor is a recent one (3.5.1 suggested – popular Ver 3.0.3 was 2002 era and did NOT of course support the 18A) and switched to the 18A mode (View >Options >Mode). The same programming cable and technique is otherwise used, although the larger memory of the 18A results in two "sweeps" as the program transfers.

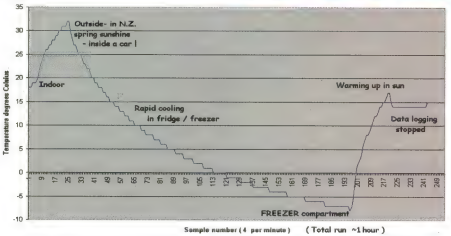
Extension

Given the deceptive simplicity of the low resolution "08" temperature data logger detailed in September, it's naturally tempting to enhance this with the high resolution "18A"/ DS18B20 combo just mentioned.

Since up to 256 values can now be directly recorded in the EEPROM (or degrees Celsius, with simultaneous display enjoyed as the data is gathered, it presents a serious device for real world data temperature monitoring – and even possible alerts if out of range values arise.

Exactly the same layout as used in the test circuit above can be used – refer to the breadboard diagram. **SC**

NEXT MONTH:
More 18A (&18X?) magic
– PC keyboard interfacing and interrupts, plus a preview of a versatile Picaxe datalogging kitset – ideal for school training or project use



Yikes! That home brew is stewing . . . a sample Excel plot from the DS18B20 and PICAXE-18 circuit used this month. This does have sufficient accuracy to be used for serious applications,

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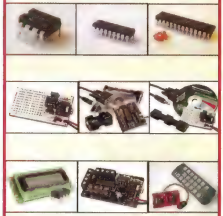

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A programmable PIC-powered timer

This PIC-based programmer can provide timing intervals from one second to over 16,320 hours (680 days) with features such as the ability to produce up to eight separate timing events with loop control, one minute on, then one second off, one hour on, one day off, one week on and more.

MASTER OF TIME

"Is it accurate?" you ask. You betcha! Hard to program, complicated and expensive to build? Not at all.

Most timers seem to be capable of only doing the one same thing, in allowing only one timing duration period with the relay either on or off during the timing cycle.

But this PIC-based timer is capable of up to eight individual ON/OFF event times of up to 2040 hours ON/OFF for each event. Seconds, minutes and hours programming in binary, with a one second resolution to boot, is all possible.

Loop control allows all timing events to run in a continuous cycle all year round.

All eight timing events are executed in a sequential fashion and therefore can be chained together to give one extremely impressive timing delay of 16,320 hours – or the best part of two years!

A LED bargraph menu display is used when programming the timer, making operation a breeze.

It can be powered from eight AA batteries or a 12VDC plugpack. All settings can be saved in EEPROM memory.

You can even configure it to automatically open and then run these pre-saved settings on power up.

Programming is achieved via a set of eight DIP switches that are used to set the various ON/OFF, seconds/minutes/hours times in BCD (Binary Coded Decimal).

If you don't know binary, it's not hard at all. Binary simply consists of BITs, (**BI**nary Digi**T**s) and in our case we are playing with eight BITs.

Each BIT has an assigned decimal value starting at 0 or 1 for BIT 1, 0 or 2 for BIT 2, 0 or 4 for BIT 3, 0 or 8 for BIT 4 and so on. The BIT values in decimal keep on doubling (ie, 1,2,4,8,16, 32,64 and 128).

By TRENT JACKSON

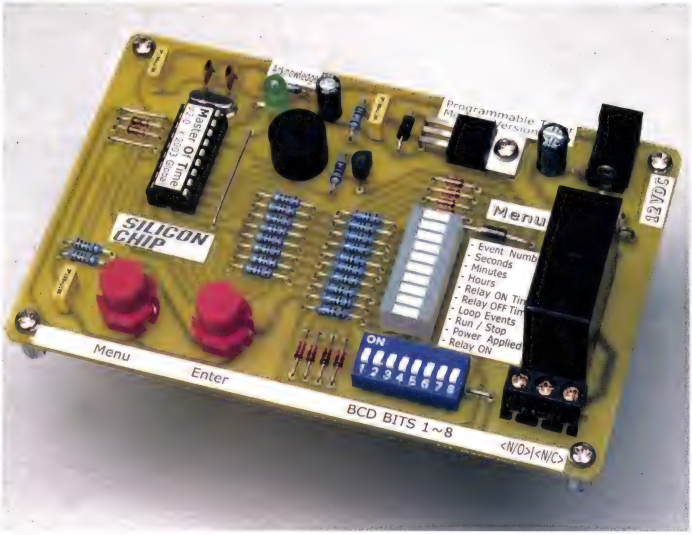
With eight BITs to play with, we can add their decimal values together to give us any number from 1 to 255.

Here's a simple example. To obtain a decimal value of 3 using our eight switches, we would use the following switch setttings: S1 = ON, S2 = ON, S3, = OFF, S4 = OFF, S5 = OFF, S6 = OFF, S7 = OFF, S8 = OFF.

To make life easy, the switch number equals the BIT number. So as you can see we are simply adding the ON/OFF status of the switches together in various combinations to achieve many different decimal numbers.

There are 255 possible combinations, thus the maximum number that we can create would be 255.

The eight DIP switches are also used to set various options and parameters for the timer during the programming



mode. We'll give more info on this later.

Circuit description

One PIC16F628 microcontroller, a 10-LED bargraph menu display, relay, piezo buzzer, DIP switches and diodes plus a handful of other low-cost components is all it really takes.

If you thought that the PIC16F84 was great, the 16F628 is even better, with double the program memory, double RAM and EEPROM and – the best part – it's even cheaper.

The PIC is clocked by a crystal at a rate of 8MHz. Ports RB0 to RB7 on the PIC are used as inputs for collecting data from the DIP switches and as outputs for driving the LED bargraph menu display. This display shows exactly what we are doing during the programming side of things.

It indicates whether we are programming the seconds/minutes/hours, ON or OFF times, and so on.

Ten 680Ω resistors limit the current to the display while eight 47kΩ resistors are used as pull-ups for RB0-RB7 when they are used as inputs. Two momentary pushbuttons are used for selecting the menu fields in the display, and entering data.

Port RA1 controls the buzzer and an Acknowledge LED (LED11) which indicates buttons being pushed and data being accepted or rejected while programming.

This LED is in series with the buzzer and a 27Ω resistor which can be increased or decreased in order to alter the volume level from the buzzer.

The number of times the Acknowledge LED flashes and the buzzer beeps indicates what is going on inside the microcontroller's brain at any given time.

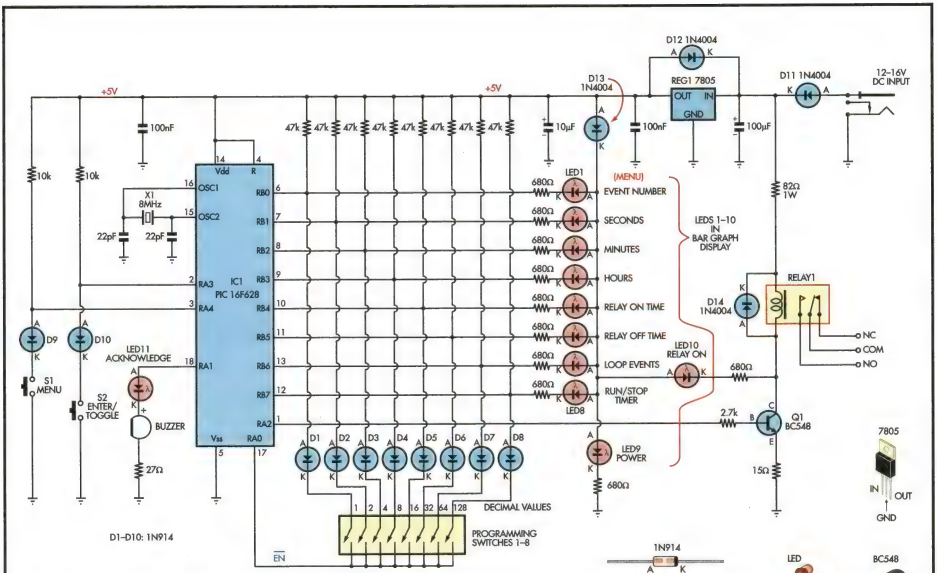
Pressing the Menu button will cause the LED to flash once and the buzzer to issue one single soft & fast chirp. Pressing the Enter button will cause the LED to flash three times and the buzzer to chirp three times as well. Invalid data will give two loud beeps.

After pressing the Enter button, the PIC will read whatever data is on the programming DIP switches and then quickly process it. If the data is invalid, there will be two loud beeps and two flashes from the LED.

Port RA0 controls the switching of the relay via transistor Q1 which is forward biased via a 2.7kΩ resistor when RA0 goes high. Diode D12 is connected across the relay coil to protect transistor Q1 from back-EMF spikes when the relay turns off.

RA2 is used to enable/disable the DIP switches. RA2 goes low when the PIC wants to read the switches. At all other times RA2 is high, to avoid the switches from interfering with the LED display.

The eight diodes that connect to PORTB are used to ensure that the



SC "MASTER OF TIME" PROGRAMMABLE TIMER

DIP switches do not interfere with the LED menu display while PORTB is used as outputs. RA0 on PORTA ensures that these diodes are reverse-biased when PORTB is set to output data to the display.

RA0 briefly swings low for a few microseconds to allow correct biasing of the diodes, to enable the switches when they need to be read.

Menu programming

All programming is achieved by following the menu system described overleaf. It really is quite simple once you get the hang of the BCD BIT values.

Massive time duration

You may wonder how we can get a time delay of 2040 hours if we are limited to 255 hours of time delay setting.

If you look at the programming chart, you will note there is a function under the "Hours ON/OFF" which sets X1, X2, X3, etc. These are the multiplication factors – what ever you set here multiplies the hours set. So if you have 200 hours set with a multiplication factor of five, you've got 1000 hours. The highest multiplication factor is eight (X8), and 8 x 255 = 2040.

But wait, there's more!

If you want even longer periods, you could set a number of events. Say you set four events with 2040 hours, you now have 8160 hours, or 340 days.

Want your Christmas Tree lights to come on for the same week each year? OK, it's crazy but it gives some idea of the flexibility of this timer.

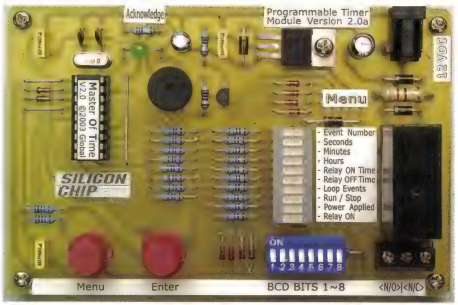
The theoretical maximum is 255 events x 2040 hours or 59.383 years. Possible? Yes it is – the PIC micro is guaranteed to retain its flash memory program for forty years, so what's a few more years between friends?

Programming event numbers easy: just get into the "Event Number" field on the menu and then select the appropriate DIP switches to the events required.

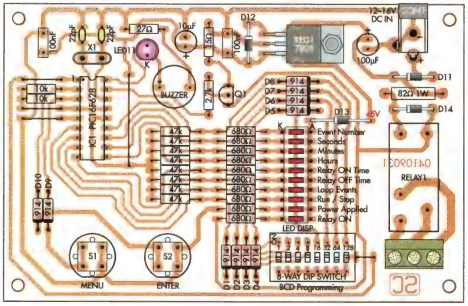
Special functions

Along with the event numbers, there are a several special functions available.

Programming in a special function option is also done by setting the DIP switches to the binary code that is allocated to the function, then pressing the "Enter" button.



All components mount on one PC board. It is strongly suggested that a socket be used for the PIC chip. There are minor differences in the prototype shown above.



If **Auto Run** is enabled then whatever data is in the non-volatile EEPROM will automatically open, load and execute at power up.

Save Data will save the current time durations and configuration data into non-volatile EEPROM.

Open Data will replace all the current settings with whatever is in the EEPROM (any data which you have entered before executing the Open Data command will be lost).

Reset Events will clear all current data that you have entered, without affecting the EEPROM. **Reset All**, on the other hand will wipe out everything *including* the data in non-volatile memory. It will also reset all options back to their defaults.

Construction

All the circuit parts are mounted on a PC board coded 04111031 and measuring 121 x 78mm.

Assembly is quite straightforward. Start with the resistors and diodes (watch the diode polarities!) and then place the larger components.

The three shorter links can be made from component lead offcuts. However, the longest link may be too long for this – you'll probably need a short length of tinned copper wire.

The two pushbutton switches must be oriented with their flat sides clos-

Parts List – Master of Time

1 PC board coded 04111031, 121 x 78mm
1 2.5mm PC-mount DC power connector
1 12VDC DPST PC-mount 240V 10A relay
2 PC-mount momentary pushbutton switches
1 3-way PC-mount terminal block connector
1 8-way DIP switch 1 8MHz crystal (X1)
1 18-pin IC socket 5 6mm x M3 machine screws
1 M3 nut & washer (for securing regulator REG1)
4 10mm x M3 standoffs
1 set of labels to suit project
1 12VDC 150mA plugpack
1 short length of tinned copper wire (PCB links)

Semiconductors

1 PIC16F628 PIC micro programmed with "MOT.hex ver 3.0" (IC1)
1 LM7805 3-terminal regulator (REG1)
1 BC548 or similar NPN transistor (Q1)
1 red 10-LED bargraph display (LED1 - 10)
1 green 5mm LED (LED 11)
10 1N914 silicon signal diodes (D1 - D10)
4 1N4004 power diodes (D11 - D14)

Capacitors

1 100µF 25V PC electrolytic
1 10µF 16V PC electrolytic
2 100nF MKT polyester
2 22pF ceramic disc

Resistors (0.25W, 1%)

2 10kΩ	8 47kΩ	1 2.7kΩ	10 680Ω
1 82Ω 1W 5%	1 27Ω	1 15Ω	

est to (and parallel with) the edge of the PC board.

Leave the semiconductors (especially the PIC chip) until last; indeed, it's a good idea to leave the PIC chip out of its socket until after checking everything. Again, take careful note of semiconductor polarity and/or orientation.

No case or other enclosure details are given – we figure that most timers would be built into whatever they are controlling.

The prototype had four 5mm threaded stand-offs to act as "feet" while checking and then as anchor points later on.

After giving the completed board a thorough visual check for both component placement and quality of soldering, you're ready to apply power and check voltages.

First, confirm that you have a +5V supply by measuring between the middle and lower legs of the 7805 regulator (this assumes that you have the switches at the bottom as shown in our drawing and photograph).

Just make sure you don't short the legs out with your multimeter probes.

Also confirm that the 5V supply is reaching the PIC chip socket – measure between pins 4 and 5.

You should also make sure that the relay is going to work when required by shorting pin 1 of the PIC socket to +5V (without the PIC in place!). This should turn on Q1, pulling in the relay.

Some relays give a good "click" when they pull in but others are very hard to hear. If you're in any doubt, rig up something to switch with the relay contacts, such as a small 12V lamp (or a LED and 1kΩ series resistor) connected across the 12V supply via the contacts.

If everything checks out OK, disconnect power, wait a few minutes for any capacitors to discharge, then plug in the PIC chip. (Do we have to mention orientation again?).

Now you're ready to start programming.

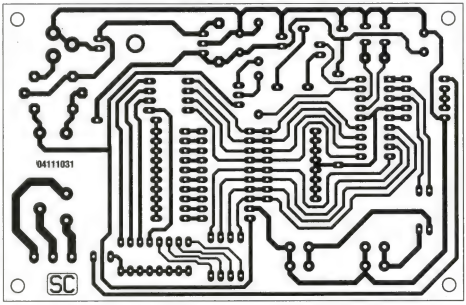
A programming example

Let's say for example that you have a pool filter that you'd like to have turn on for two hours every day of the year.

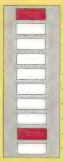
OK, let's assume that power is applied and the hours ON/OFF is set to the X1 factor and the Event Number LED is on in the menu. By the way, X1 is the default.

First, start by selecting event DIP switch 1. It should be ON; all the rest set to OFF. Press the Enter (S2) button, followed by pressing the Menu button (S1) until the Hours & Relay ON Time LEDs are ON.

Now set DIP switch 2 ON and all the rest OFF, press Enter again and then Menu until the Hours & Relay OFF Time LEDS are now ON.



Software Menu System Explained



When power is applied, the PIC will initiate a simple self test. All the LEDs will briefly light and the buzzer will chirp. Then the Event Number and Power Applied LEDs will be on. Toggling the "Menu" button allows selection of the various items within the menu system. Pressing the "Enter" button causes the software to read the status of the DIP switches and place the data into the currently selected field. The first item in the menu structure is the "Event Number", which has a default of 1. Unless we want to program in data for another event, we can skip this menu item by pushing the "Menu" button. Everything except "Event Number" assumes a default value of 0 (zero). There is no need to erase previous settings – you simply write over them with new values. And if you don't need to use a particular menu item (such as "Hours"), simply leave it set to the default.

The basic data entry format is Seconds/Minutes/Hours for both Relay ON and Relay OFF times.

Here's what you can expect to see after pushing the "Menu" button for the first time. Use the 8 DIP switches to select the number of seconds (in binary), then press "Enter", followed by "Menu".

Minutes, Relay ON Time field: It is as you did with the seconds, except now enter the number of minutes that you want for the current event, then press "Enter", followed by "Menu".

Enter the number of hours that you require. Remember, if you don't want hours (or any other parameter) simply press "Menu" to skip it. Provided that no data already exists, any field (except "Event Number") will default to zero.

Next is the "Relay OFF Time". It is simply the amount of time that the relay stays off until the next event is executed. So if you want an event to occur at the same time tomorrow and your "Relay ON Time" is 3:30:00, the "Relay OFF Time" would be 20:30:00. Press "Enter" then "Menu" to move on.

Now enter the number of minutes that you require the relay to be off. Made a mistake, or want to change a value in a field? Simply write over it and press the "Enter" button.

Last in the time setting functions is the Relay Off Hours. The hours x option can be used to create enormous delays – up to 2040 hours for each event. Refer to the binary special functions chart for more info.

The "Loop Events" function can be used to cycle the events to run continuously. Toggle "Enter" to enable or disable it. When it is enabled, the LED will flash (default is disabled).

Ready for action? Let's run this baby! Toggle "Enter" to start/stop execution of your program. The LED will flash while it is running. Stop the timer and press Menu to go back to "Event Number"

Now we need to set in an OFF time of 22 hours. With 24 hours in a day, we want it ON for two hours and OFF for 22 hours. In 8-bit binary that number would be 00010110. BITs 2, 3 & 5 will need to be set, therefore switches 2, 3 & 5 must be set ON, all the rest set OFF.

Do that, then press Enter and use the Menu button to scroll down to Loop Events. Toggle Loop Events ON by pressing Enter.

Then it's just a matter of pressing Menu again to go down to Run/Stop, followed by Enter.

If all is well, the relay should switch ON for two hours then switch OFF for 22 hours, then repeat the cycle over and over again until you hit the Enter button again to break the timing loop.

RELAY ON / OFF TIME DURATIONS BINARY PROGRAMMING CHART

DIP Switch	1	2	3	4	5	6	7	8
Dec Value	1	2	4	8	16	32	64	128
Sec/Min/Hr	Select the desired Sec/Min/Hr field on the Lcd menu display by toggling the menu button. Set the appropriate Dip switch codes in for your desired delay times, then press the "Enter" button							
1	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
2	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
3	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF
4	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF
5	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF
6	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF
7	ON	ON	ON	OFF	OFF	OFF	OFF	OFF
8	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF
9	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF
10	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF
11	ON	ON	OFF	ON	OFF	OFF	OFF	OFF
12	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF
13	ON	OFF	ON	ON	OFF	OFF	OFF	OFF
14	OFF	ON	ON	ON	OFF	OFF	OFF	OFF
15	ON	ON	ON	ON	OFF	OFF	OFF	OFF
16	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF
17	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
18	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF
19	ON	ON	OFF	OFF	ON	OFF	OFF	OFF
20	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF
21	ON	OFF	ON	OFF	ON	OFF	OFF	OFF
22	OFF	ON	ON	OFF	ON	OFF	OFF	OFF
23	ON	ON	ON	OFF	ON	OFF	OFF	OFF
24	OFF	OFF	OFF	ON	ON	OFF	OFF	OFF
25	ON	OFF	OFF	ON	ON	OFF	OFF	OFF
26	OFF	ON	OFF	ON	ON	OFF	OFF	OFF
27	ON	ON	OFF	ON	ON	OFF	OFF	OFF
28	OFF	OFF	ON	ON	ON	OFF	OFF	OFF
29	ON	OFF	ON	ON	ON	OFF	OFF	OFF
30	OFF	ON	ON	ON	ON	OFF	OFF	OFF
31	ON	ON	ON	ON	ON	OFF	OFF	OFF
32	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF
33	ON	OFF	OFF	OFF	OFF	ON	OFF	OFF
34	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF
35	ON	ON	OFF	OFF	OFF	ON	OFF	OFF
36	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF
37	ON	OFF	ON	OFF	OFF	ON	OFF	OFF
38	OFF	ON	ON	OFF	OFF	ON	OFF	OFF
39	ON	ON	ON	OFF	OFF	ON	OFF	OFF
40	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF
41	ON	OFF	OFF	ON	OFF	ON	OFF	OFF
42	OFF	ON	OFF	ON	OFF	ON	OFF	OFF
43	ON	ON	OFF	ON	OFF	ON	OFF	OFF
44	OFF	OFF	ON	ON	OFF	ON	OFF	OFF
45	ON	OFF	ON	ON	OFF	ON	OFF	OFF
46	OFF	ON	ON	ON	OFF	ON	OFF	OFF
47	ON	ON	ON	ON	OFF	ON	OFF	OFF
48	OFF	OFF	OFF	OFF	ON	ON	OFF	OFF
49	ON	OFF	OFF	OFF	ON	ON	OFF	OFF
50	OFF	ON	OFF	OFF	ON	ON	OFF	OFF
51	ON	ON	OFF	OFF	ON	ON	OFF	OFF
52	OFF	OFF	ON	OFF	ON	ON	OFF	OFF
53	ON	OFF	ON	OFF	ON	ON	OFF	OFF
54	OFF	ON	ON	OFF	ON	ON	OFF	OFF
55	ON	ON	ON	OFF	ON	ON	OFF	OFF
56	OFF	OFF	OFF	ON	ON	ON	OFF	OFF
57	ON	OFF	OFF	ON	ON	ON	OFF	OFF
58	OFF	ON	OFF	ON	ON	ON	OFF	OFF
59	ON	ON	OFF	ON	ON	ON	OFF	OFF
60	OFF	OFF	ON	ON	ON	ON	OFF	OFF

*Up to 255 BIT combinations codes are possible. (1-60) Should be sufficient in most cases.

(1 - 8) TIMING EVENT SELECTION BINARY PROGRAMMING CHART

DIP Switch	1	2	3	4	5	6	7	8
Dec Value	1	2	4	8	16	32	64	128
Event Num								
*1	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
2	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
3	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF
4	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF
5	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF
6	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF
7	ON	ON	ON	OFF	OFF	OFF	OFF	OFF
8	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF

* Event "1" is default, if no event number is selected, the data will be placed in event "1" location

SPECIAL FUNCTION OPTIONS BINARY PROGRAMMING CHART

DIP Switch	1	2	3	4	5	6	7	8
Dec Value	1	2	4	8	16	32	64	128
Function	To enter into options mode: Select "Event Number" in menu, set all switches "ON" press Enter button, Event Number Led will flash. Now enter in the function codes, Menu button to exit mode.							
*Hours ON X1	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF
Hours ON X2	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF
Hours ON X3	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF
Hours ON X4	OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF
Hours ON X5	ON	OFF	ON	OFF	OFF	OFF	OFF	OFF
Hours ON X6	OFF	ON	ON	OFF	OFF	OFF	OFF	OFF
Hours ON X7	ON	ON	ON	OFF	OFF	OFF	OFF	OFF
Hours ON X8	OFF	OFF	OFF	ON	OFF	OFF	OFF	OFF
*Hours OFF X1	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF
Hours OFF X2	OFF	ON	OFF	ON	OFF	OFF	OFF	OFF
Hours OFF X3	ON	ON	OFF	ON	OFF	OFF	OFF	OFF
Hours OFF X4	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF
Hours OFF X5	ON	OFF	ON	ON	OFF	OFF	OFF	OFF
Hours OFF X6	OFF	ON	ON	ON	OFF	OFF	OFF	OFF
Hours OFF X7	ON	ON	ON	ON	OFF	OFF	OFF	OFF
Hours OFF X8	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF
Save Data	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF
Open Data	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF
Auto Run ON	ON	ON	OFF	OFF	ON	OFF	OFF	OFF
*Auto Run OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	OFF
Reset Events	ON	OFF	ON	OFF	ON	OFF	OFF	OFF
Reset "ALL"	OFF	ON	ON	OFF	ON	OFF	OFF	OFF

Options default values. Reset "ALL" function, deletes all saved data & restores factory defaults

*** If you don't wish to erase all of the timing data in any given event, you can just erase what you don't require in a menu field by setting all the switches to "OFF" and then pressing "Enter". This effectively sets the timing interval to zero and therefore will not be executed as a delay (the software will see a value of "0" and skip it automatically).**

Wheredyagedit?

This project was developed by the author for Global Unlimited Pty Ltd, who retain copyright in the PIC microcontroller code but have released the PC board and circuit.

Global Unlimited have three different kits available which should meet the needs of most constructors.

Kit 1 includes all components, the PC board, etc (but does not include a plugpack) for $64.95 including GST.

Kit 2 is the same but is pre-built and tested and includes a 12-month warranty, for $89.95 including GST.

Finally, for those who wish to "do their own thing" they have the pre-programmed PIC 16F628 microcontroller available for $24.00 (inc GST).

All prices include packing and postage to anywhere in Australia (allow up to 28 days for delivery). Cheques should be made payable to Global Unlimited Pty Ltd.

Global Unlimited can be contacted on (02) 4566 3218, or (02) 4566 3168. Their postal address is PO Box 3286, Dural NSW 2158. **SC**

PC BOARD DESIGN TUTORIAL

Here's the second part of our short series on designing your own PC bards. This month, we take up from where we left off with component placement and design.

Part 2 – by David L. Jones

It's often said that PC board design is 90% placement and 10% routing. While the actual figures are of no importance, the concept that component placement is by far the most important aspect of laying out a board, certainly holds true.

Good component placement will make your layout job easier and give the best electrical performance. Bad component placement can turn your routing job into a nightmare and give poor electrical performance – perhaps not even work at all. It may even make your board unmanufacturable. So there is a lot to think about when placing components!

Every designer has their own method of placing components. If you gave the same circuit (no matter how simple) to 100 different experienced designers, you're likely to get 100 different PC board layouts.

So there is no absolute right way to place your components. It's largely a matter of experience. But there are quite a few basic rules which will help ease your routing, give you the best electrical performance and simplify large and complex designs.

Getting down to basics

Here are some basic steps required for laying out a complete board:

- Set your snap grid, visible grid, and default track/pad sizes.
- Throw down all the components onto the board.
- Divide and place your components into functional "building blocks" where possible.
- Identify critical tracks on your circuit and route them first.
- Place and route each building block separately, off the board.
- Move completed building blocks into position on your main board.
- Route the remaining signal and power connections between blocks.
- Do a general "tidy up" of the board.
- Do a Design Rule Check.
- Check your board thoroughly.
- Then get someone else to check it!

This is by no means a be-all and end-all check list – it's highly variable depending on many factors. But it is a good general guide to producing a first-class layout.

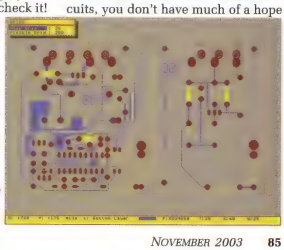
A bit more detail

Let's look in more detail at the procedure described above.

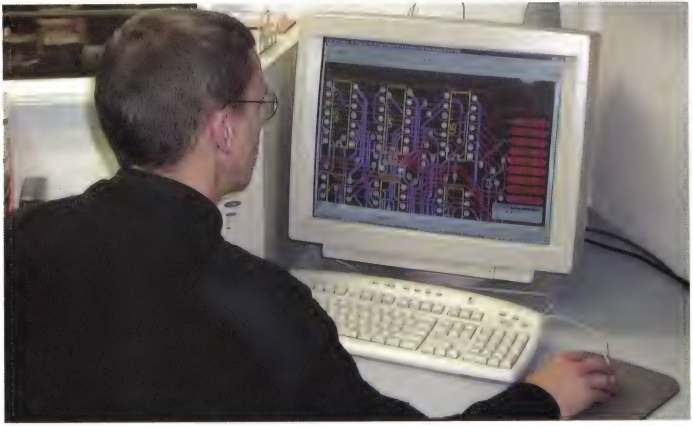
We have already looked at the grids and track/pad sizes. These should be the first things that you set up before you start doing anything. No exceptions!

Many people like to jump straight into placing all the components into what they think is the most optimum position on the board, all in one hit.

While this can work for small circuits, you don't have much of a hope



The very first step in designing a PC board using any PC board software is to set the snap grid, visible grid and default track/pad sizes. This screen (from the popular "Autotrax" freeware) shows how it is done. Other software packages will have similar settings.



when you have more complex circuits with hundreds of components spread across many functional circuit blocks.

Why? Because it's very easy to run out of "routing space" which is the room to lay down all your tracks. If you fix all your component positions and then try to route everything, you can easily paint yourself into a corner, so to speak.

Alternatively, if you space the components out too much, you can end up with a large board that does not make efficient use of space.

The hallmark of an inexperienced designer is a board that has every component evenly spaced out and then has thousands of tracks and links or vias criss-crossing the board. It might work but it can be ugly and inefficient, not to mention bigger and more expensive to manufacture.

The best way to start your layout is to get ALL of your components onto the screen first.

If you have a companion schematic package, then the simplest way to do this is to get your PC board program to import your schematic design and select all the components automatically. This will also be discussed later. If all you have is a PC board program, then you'll have to select each component from the library and place them manually.

With all the components on screen, you should get a good indication of whether or not your parts will easily fit onto the size (and shape) of board that you require.

If it looks like it's going to be a tight fit, then you know that you will have to work hard to try and keep the component spacing "tight" and the tracking as efficient as possible. If it looks like you have plenty of room, then you can be a bit more liberal in your layout. Of course, if it looks like you have Buckley's chance of getting your components on the board, you'll have to go back to the drawing board.

Now analyse your schematic and determine which parts of the design can be broken up into "building blocks". Often this is fairly obvious.

For example, say you have a complex-looking active filter in your circuit. This would typically have a single input line and a single output line but will have lots of components and connections as part of the filter. This is a classic "building block" circuit and one that lends itself well to combining all of these parts together in the same location. So you would grab all of these parts and start to arrange them into their own little layout off to one side of your board. Don't worry too much about where the actual block goes on your board yet.

You will also need to partition off electrically sensitive parts of your design into bigger blocks. One major example is with mixed digital and analog circuits. Digital and analog just do not mix and will need to be physically and electrically separated.

Another example is with high frequency and high current circuits; they do not mix with low frequency and low current sensitive circuits. We'll have more about this later.

As a general rule, your components should be neatly lined up: ICs in the same direction, resistors in neat columns, polarised capacitors all around the same way and connectors on the edge of the board.

Don't do this at the expense of having an electrically poor layout or an overly big board though. Electrical parameters should always take precedence over nicely lined up components.

Symmetry is really nice in PC board design. If you have something like two identical building block circuits side by side and one is laid out slightly differently, it sticks out like a sore thumb.

If you have placed your compo-

nents wisely, 90% of your work will be done. The last 10% is just joining the dots, so to speak. Well, not quite – but good placement is a good majority of your work done.

Once you are happy with the component placements, you can start to route all the different building blocks separately. When finished, it is then often a simple matter to move and arrange the building blocks into the rest of your design.

The Design Rule Check (DRC) will be covered later but it is an essential step to ensuring that your board is correct before manufacture. A DRC basically checks for correct connectivity of your tracks and for correct widths and clearances.

Getting someone to check your board may sound like an overly bureaucratic process but it really is a vital step. No matter how experienced you are at PC board design, there will always be something you overlooked. A fresh pair of eyes and a different mindset will pick up problems you would never see.

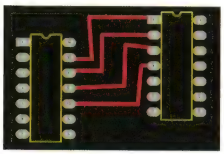
If you don't have anyone to check your board over, then you'll have to do it yourself. Get a printout of your schematic and a highlighter pen. Now, compare every single electrical "net" connection (connection between two points) on your board with the schematic, net by net. Highlight each net on the schematic as you complete it.

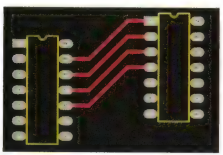
When you are finished, there should be no electrical connections left that aren't highlighted. You can now be fairly confident that your board is electrically correct.

Basic routing

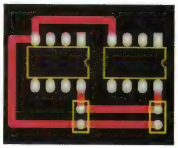
Now it's time for some basic routing rules. Routing is also known as "tracking". Routing is the process of laying down tracks to connect components on your board. An electrical connection between two or more pads is known as a "net".

- Keep nets as short as possible. The longer your total track length, the greater its resistance, capacitance and inductance – all of which can be undesirable factors.
- Tracks should only have angles of 45°. Avoid the use of right angles and in no circumstances use an angle greater than 90°. This is important to give a professional and neat appearance to your board. PC board packages will have a mode to enforce 45° movements – make use of it. There should never be a need to turn it off. Contrary to popular belief, sharp right angle corners on tracks don't produce measurable EMI or other problems. The reasons to avoid right angles are much simpler – it just doesn't look good and it may have some manufacturing implications.
- Forget nice rounded track corners, they are harder and slower to place and have no real advantage. Stick to 45° increments. Rounded track bends belong to the pre-CAD taped artwork era.
- "Snake" your tracks around the board – don't just go "point to point". Point to point tracking may look more efficient to a beginner at first but there are a few reasons you shouldn't use it. The first is that it's ugly, always an important factor in PC board design! The second is that it is not very space-efficient when you want to run more tracks on other layers.
- Enable your electrical grid, which is sometimes referred to as a "snap to centre" or "snap to nearest" option. Let the software find the centres of pads and ends of tracks automatically for you. This is great for when you have pads and tracks which aren't lined up to your current snap grid. If you don't have these options enabled then you may have to keep reducing your snap grid until you find one that fits – far more trouble than it's worth. There is almost never a reason to have these options disabled.
- Always take your track to the centre of the pad; don't make your track and pad "just touch". There are a few reasons for this. The first is that it's sloppy and unprofessional. The second is that your program may not think that the track is making electrical connection to the pad. Third, with surface mount components, an off-centre track-pad connection can again cause solder surface tension to pull the component out of alignment. Proper use of a snap grid and electrical grid will avoid problems here.
- Use a single track, not multiple tracks tacked together end to end. It may make no difference to the look of your final board but it can be a pain for future editing. Often you'll have to extend a track a bit. In this case, it's best to delete the old one and place a new one. It may take a few extra seconds but it's worth it. People looking at your finished board may not know but *you* will know! It's the little touches like this that set good PC board designers apart.
- Make sure your tracks go right through the exact centre of pads and components, and not off to

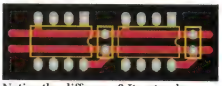




Both of these PC boards are electrically identical; both would of course work the same. But you can see instantly just how much better the board on the right looks with the tracks following the 45° design rule.



In this case, the bypass capacitors on the power rails are too far removed from the supply pins on the ICs.



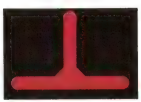
Notice the difference? It not only looks neater and also takes up a lot less real estate – it will work better!

one side. Use of the correct snap grid will ensure that you get this right every time. If your track doesn't go through the exact centre then you are using the wrong snap grid. Why do you need to do this? It makes your board neater and more symmetrical and it gives you the most clearance.

- Only take one track between 100 thou pads unless absolutely necessary. Only on large and very dense designs should you consider two tracks between pads. Three tracks between pads is not unheard of but we are talking seriously fine tolerances here.
- For high currents, use multiple vias when going between layers. This will reduce your track impedance and improve the reliability. This is a general rule whenever you need to decrease the impedance of your track or power plane.
- Don't "drag" tracks to angles other than 45°
- "Neck down" between pads where possible. Eg, a 10 thou track through two 60 thou pads gives a generous 15 thou clearance between track and pad.
- If your power and ground tracks are deemed to be critical, then lay them down first. Also, make your power tracks as BIG as possible.
- Keep power and ground tracks running in close proximity to each other if possible, don't send them in opposite directions around the board. This lowers the loop inductance of your power system, and allows for effective bypassing.
- Keep things symmetrical. Symmetry in tracking and component placement is really nice from a professional aesthetics point of view.
- Don't leave any unconnected copper fills (also called "dead copper"), ground them or take them out.

If you are laying out a non-plated-through double-sided board, then there are some additional things to watch out for. Non-plated-through holes require you to solder a link through the board on both the top and bottom layer.

- Do not place vias under components. Once the component is soldered in place you won't be able to access the joint to solder a feed through. The solder joint for the feed through can also interfere with the component.
- Try to use through-hole component legs to connect top tracks to bottom tracks. This minimises the number of vias. Remember that each via adds two solder joints to your board. The more solder joints you have, the less reliable your board becomes, not to mention that that it takes a lot longer to assemble.



Adding a chamfer to a "T" junction doesn't just look neater, it helps prevent undercutting.

Finishing Touches:

Even though you have finished all your routing, your board isn't yet complete. There are a few last minute checks and finishing touches you should do.

- If you have thin tracks (<25 thou) then it's nice to add a "chamfer" to any "T" junctions, thus eliminating any 90° angles. This makes the track more physically robust, and prevents any potential manufacturing etching problems. But most importantly, it looks nice.
- Check that you have any required mounting holes on the board. Keep mounting holes well clear of any components or tracks. Allow room for any washers and screws (especially when it comes to mains voltage clearances).
- Minimise the number of hole sizes. Extra hole sizes cost you money, as the manufacturer will charge you based on not only the number of holes in your boards but the number of different hole sizes you have. It takes time for the very high-speed drill to spin down, change drill bits and then spin up again. Check with your manufacturer for these costs, but you can't go wrong by minimising the number of hole sizes.
- Double check for correct hole sizes on all your components. Nothing is more annoying than getting your perfectly laid out board back from the manufacturer, only to find that a component won't fit in the holes! This is a very common problem; don't get caught out.
- Ensure that all your vias are identical, with the same pad and hole sizes. Remember your pad-to-hole ratio. Errors here can cause "breakouts" in your via pad, where the hole, if shifted slightly can be outside of your pad. With plated through holes this is not always fatal, but without a complete annular ring around your hole, your via will be mechanically unreliable.
- Check that there is adequate physical distance between all your components. Watch out for components with exposed metal that can make electrical contact with other components, or exposed tracks and pads.
- Change your display to "draft" mode, which will display all your tracks and pads as outlines. This will allow you to see your board "warts and all", and will show up any tracks that are tacked on or not ending on pad centres.
- If you wish, add "teardrops" to all your pads and vias. A teardrop is a nice "smoothing out" of the junction between the track and the pad and is, not surprisingly, shaped like a teardrop. This gives a more robust and reliable track to pad interface, better than the almost right angle between a standard track and pad. Don't add teardrops manually though, it's a waste of time. But if your program supports automatic teardrop placement, feel free to use it.

Likewise, "teardrops" added to the joins between tracks and pads looks neater and also helps prevent etching problems.

Single-sided PC board design

Single-sided design can greatly reduce the cost of your board. If you can fit your design on a single sided board then it is preferable to do so. Look inside many of today's consumer items like TVs and DVD players, and you will almost certainly find some single-sided boards.

Just about all of SILICON CHIP's boards are single-sided. They are still used because they are so cheap to manufacture. And in the case of SILICON CHIP boards, single sided are much easier for those who wish to make their own from the printed patterns or downloaded web files.

Single-sided design requires some unique techniques which aren't required once you go to doubled-sided and multi-layer design. It is certainly more challenging than a double-sided layout.

Probably the biggest differences is that some links (jumpers) may be required when it is impossible to avoid tracks crossing over one another. However, links should be avoided if at all possible. In fact, a single-sided board design will be regarded inversely proportional to the number of jumper links used. "No links" earns the admiration of many peers!

Component placement can be even more critical on a single-sided board, so it won't always be possible to have all your components nice and neatly aligned. Arrange your components so that they give the shortest and most efficient tracking possible.

It is like playing a game of Chess; if you don't think many moves ahead then you will get yourself in a corner pretty quickly. Having just one track running from one side of your board to the other can ruin your whole layout, as it makes routing any other perpendicular tracks impossible.

Many designers will route their board as though it is a double-sided board but only with straight tracks on the top layer. Then when the board is to be manufactured, the top layer tracks are replaced with jumper links.

This can be a rather inefficient way to approach single sided design and is not recommended. You must be frugal in your placement, and don't be afraid to rip everything up and try again if you see a better way to route something.

Double-sided PC board design

Double-sided PC board design gives an extra degree of freedom for designing your board. Things that are next to impossible on a single-sided board become relatively easy when you add an additional layer.

Many (inexperienced) designers tend to become lazy when laying out double-sided boards. They think that component placement doesn't matter and that hundreds of vias can be used to get them out of trouble. They will often lay out components like ICs in neat rows and then proceed to route everything using right angle rules.

This means that they will route all the tracks on the bottom layer in one direction and then all the tracks on the top layer perpendicular to the bottom layer. The theory is that if you chop and change between layers enough times you can route almost anything using a "step" type pattern.

This technique can be ugly and inefficient and is a throwback to the old manual tape days. Many basic PC "auto routers" work in this way.

Stick to using good component placement techniques and efficient building block routing. Double-sided design can also give you the chance to make use of good ground plane techniques, required for high frequency designs. This will be discussed later.

That's all for this month. Next we will look at more advanced topics like multi-layer boards, ground planes, high frequency design, auto routing and design for manufacturing. **SC**

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VINTAGE RADIO

By RODNEY CHAMPNESS, VK3UG

The 4-valve Precedent mantel receiver (circa 1953)

Designed for those on a budget, the 4-valve Precedent mantel receiver was released onto the Australian market in the early 1950s. It's a relatively simple set with many cost-cutting features but it still worked quite well in suburban areas.

A. W. JACKSON INDUSTRIES of Sydney produced Precedent radios and B & W TV receivers from the 1950s until somewhere about 1975, when colour TV was introduced into Australia.

The receivers were aimed at the lower end of the market. In fact, many people looked down on the brand and wouldn't be seen dead selling or using such receivers. But although they were cheaper than other brands, they were remarkably reliable, had simple circuitry that worked quite well, and were generally easy to service. However, they certainly were not the Rolls Royce of radios.

The 4-valve receiver featured in this article was in a rather sorry state when it first came to me, as can be seen in the photographs. The cabinet was cracked, the works were covered in a layer of muck, the power lead had perished and exposed power wires were quite evident at the back of the set. In addition, parts of the chassis and the power transformer were showing extensive rust.

However, things were much better under the chassis, with only a number of cobwebs to be removed. Even so, it was obvious that quite a challenge lay ahead of me to restore the receiver. It would never be a valuable set but would be an interesting one just the same.

This is the 4-valve Precedent mantel set before restoration. Its cabinet had a bad crack at the top and was held together by masking tape.

Essential checks

The first job was to make sure that the power transformer was in good condition – especially since its case was badly rusted. This was one set that would not be valuable enough to restore if its power transformer was faulty, unless a similar transformer was readily available.

As a result, the transformer was carefully tested with my high voltage tester. This involved checking for high-voltage breakdown between the various windings and the transformer frame. It all checked out OK.

Next, the audio output transformer windings were checked for continuity. In this case, a replacement would be required, as the primary winding was open circuit. By contrast, the intermediate frequency (IF) transformers and the aerial and oscillator coils all had continuity, so the restoration would not require any "hard-to-get" replacement parts.

Cleaning up

Unfortunately, the cabinet top had

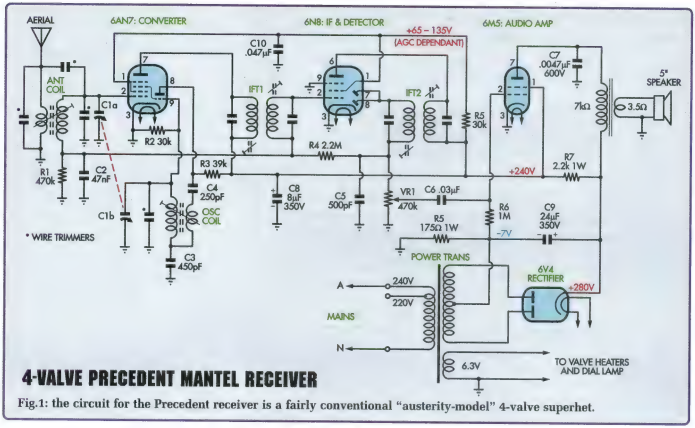

Fig.1: the circuit for the Precedent receiver is a fairly conventional "austerity-model" 4-valve superhet.

cracked and it had been "repaired" using masking tape. Obviously, a much better repair was needed and so the cabinet was scraped clean of the masking tape and then placed into the laundry wash tub, together with the knobs. It was then thoroughly cleaned using a scrubbing brush and soapy water.

The cabinet was then rinsed in clean water as the cracks needed to be free of any "muck" before being glued together later on. Both the cabinet and knobs looked first class after cleaning and were then set aside so that other work could be done.

The valves were also cleaned using soapy water but you have to make sure that the type numbers don't get rubbed off during this process. This involves holding the valves upside down (to keep water out of the socket) and then gently washing the envelopes but completely avoiding the type numbers.

That done, the valves were rinsed in clean water and left to dry. Valves really do look good after they have been cleaned!

After they had dried, I scratched between pins 1 & 2 of the 6M5 with a screwdriver so that any silver migration between grid and screen would be disrupted. This prevents positive voltage being applied to the grid. It might sound like a strange thing to do but 6M5s have been known to have silver migration between these pins, which means that the valves are often (needlessly) thrown out because they are thought to be "gassy".

This view shows the state of the chassis. It was covered in a layer of dirt, the power lead had perished (exposing the wires) and parts of the chassis and the power transformer were covered in rust.

The next job was to clean up the chassis. It was quite rusty in spots but I stuck to my usual cleaning techniques. First, the chassis was dusted using a small paintbrush, after which I "huffed and puffed" and blew out as much dust as I could. Of course, a small compressor would be ideal for

The restored receiver is barely recognisable from the rather sorry mess that arrived in my workshop. The cabinet was repaired using fibreglass mixed with cream craft paint.

this job but I don't have one, unfortunately.

The next stage of the cleaning procedure involved using a kerosene-soaked kitchen scourer (or a segment of one) to scrub the chassis as thoroughly as I could. I use a screwdriver to push the scourer into odd corners and the end result, after wiping the chassis down with a rag, was a marked improvement in the appearance of the set.

In this case, I decided against painting the chassis, as this set isn't valuable enough to warrant this type of effort. The fact that it is quite rusty shows that the chassis wasn't well-plated in the first place.

Next, the dial scale was cleaned with a damp rag and it came up quite well. However, the method used to indicate the pointer location on the dial drive system is primitive to say the least. The pointer used is the common slide type, however it cannot normally be seen through the scale. So, in order to indicate the pointer position, a dial lamp is set back by about 50mm behind the scale and the shadow cast by the pointer on the scale indicates the tuning.

Unfortunately, because the lamp position is fixed, the shadow is quite hard to see at the extremities of the tuning range. In addition, parallax error greatly affects the tuning accuracy at the dial extremities.

Of course, this probably didn't matter for a cheap kitchen or garage radio, as most of the time it would simply be left on the favourite radio station.

In its favour, the dial drive mechanism is cheap and works reasonably well, although it does suffer from increased resistance at the low frequency end of the dial. In my case, I was just getting it all functioning correctly when the cord broke, so I ended up having to re-string the dial drive (not the easiest of jobs). In addition, the globe behind the dial scale had blown and had to be replaced.

Overhauling the circuitry

Having a circuit to follow always makes servicing so much easier but I couldn't find this set in any of the Australian Official Radio Service Manuals I consulted.

According to the markings on the loudspeaker transformer, it was probably made in 1953 but I was unable to find a circuit anywhere. In the end, I had to trace the circuit out with the aid of a valve data book and a multimeter. Fig.1 shows the details and as can be seen, it is a conventional "austerity model" 4-valve superhet.

Getting back to the set, the original 2-core mains lead had perished. **It was replaced with a 3-core lead, so that the chassis could be earthed in the interests of safety.** That done, the valves were all removed and the receiver then plugged into power.

A quick check with a DMM showed that all windings on the transformer were delivering the correct voltages and there were no signs of overheating, even after it had been running for some time. This indicated that there were no shorted turns in the windings.

As mentioned earlier, the speaker transformer was faulty and so it was replaced with an M1100 "Audio Line Transformer" from Dick Smith Electronics. The plate circuit was wired across the 5kΩ winding, while the speaker was connected to the 2Ω secondary. This gives a reasonable impedance ratio compromise between the primary (6M5 plate) and the secondary load (ie, the speaker).

Leaky electrolytic

A quick check with a DMM showed a high resistance (over 50kΩ) between the high-tension (HT) line and the chassis. That cleared the HT line of any shorts, so the multimeter was switched to the 400V range and one lead connected to chassis via a clip lead. That done, the 6V4 rectifier was plugged in, the set turned on and the voltages across the 24μF (C9) and 8μF (C8) capacitors were checked.

This quickly showed that the voltage across the 8μF capacitor wasn't rising to the correct value. And when the power was turned off, the voltage across this capacitor quickly disappeared. The reason for this was straightforward – the capacitor was leaky and in fact showed 12mA of leakage current after several on-off cycles.

Just to confirm it was faulty, I removed it and checked the circuit again. This time, the 24μF capacitor discharged slowly when the power was removed so it was in good condition. A replacement 8μF capacitor fixed the problem and the power supply then worked correctly.

Next, the paper capacitors were all checked but only one was found to be excessively leaky. This time, the culprit was C6, a .03μF audio coupler to the 6M5 grid. It too was replaced.

Having done all that, the other three valves were plugged in and the set

Photo Gallery: Zenith Radio Calstan Receiver (1947)

Manufactured by Zenith Radio Co Pty Ltd (Sydney) in 1947, the Calstan was a medium-sized, 5-valve receiver which was housed in a handsome timber cabinet. It used the following valve line-up: 6A8-G frequency changer; 6U7-G IF amplifier; 6B6-G detector, AVC rectifier and 1st audio amplifier; 6V6-GT audio output stage; and a 5Y3-GT rectifier. The Calstan brand was also well-known at the time for a range of test equipment, the word being an abbreviation of the phrase "calibrated-to-standard". (Photo courtesy Historical Radio Society Of Australia (Inc.).

switched on again. It quickly burst into life, with stations appearing right across the dial. Fairly obviously, all the valves were in good order - in fact, I find I have to replace very few valves in these old receivers.

Annoying whistle

Unfortunately, that wasn't the end of the set's problems. It had only been on a short while when it started to whistle on all the stations, particularly those in the middle of the dial. The volume control did have some effect on these whistles and it was obvious that the IF stage was oscillating.

OK, so how could the set be made stable? First, I tried installing a new screen bypass capacitor from pin 1 of the 6N8 to earth and while that improved matters somewhat, the instability was still there. And as a matter of interest, the original paper capacitor had been fitted incorrectly, as its outer foil (shield) was connected to pin 1 of the 6N8 instead of to earth.

My next suspect was the .0047µF plate bypass capacitor (C7) on pin 7 the 6M5 audio output stage. Its job is to get rid of any IF (455kHz) components in the audio, so I tried another capacitor here and the whistle stopped. It's worth noting that neither of the original capacitors was excessively leaky (electrically) but it would appear that they were more inductive than the later types that were substituted.

By now, the little Precedent receiver was bringing in the stronger stations at very good volume. However, the volume control to be advanced quite a bit for the weaker stations so I decided to take a close look at the automatic gain control (AGC) system.

The AGC system used in this set is actually quite simple. However, it is a bit strange in that only one fifth of the developed AGC voltage is actually applied to the 6N8 and 6AN7 valves by virtue of the voltage divider formed by resistors R1 and R4. This was done to ensure that the AGC-controlled valves worked at nearly at full performance – even with strong signals – so that good audio volume could be achieved.

A few quick checks showed that with R1 in circuit, the AGC voltage at the detector is about -27V on the strongest local station. Conversely,

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This 1958 5-valve radiogram chassis shows the quality improvements that Precedent made to its later model sets. Its dial mechanism is light years ahead of the 4-valve mantel set's dial-drive system.

with R1 disconnected, the voltage is only about -9V but the audio output is more even on all stations, with no "blasting" when tuning to a strong station.

At the time, this made me wonder if R1 had been added by a serviceman at some stage during the set's life to boost the audio output for suburban use. However, I subsequently came across another 4-valve set that uses a similar AGC circuit, so perhaps it is original.

In my case, I decided to leave out R1 as this gave better performance. Resistor R4 had also gone high in value and was replaced.

Unusual effect

As an aside, it's interesting to note that a rather unusual effect would have occurred if C6 had not been replaced. Because it had gone leaky, this capacitor would have passed some of the negative DC output from the detector to the grid of the 6M5 audio output stage. As a result, the 6M5 would have progressively been cut off as the volume control was increased on a strong station, resulting in decreased or no audio!

Note that neither the 6AN7 nor the 6N8 have any bias applied to them in the absence of a signal. This means that the receiver must to be tuned to a station in order for AGC bias to be applied to these valves. However, the set's designer could have applied delayed AGC and back bias to these two valves by adding just two extra resistors and a 47pF mica capacitor. It would have meant a very small increase in complexity for a better performing AGC system.

By now the set was performing quite well and so it was left to run on the bench to see if anything else showed up. As it turned out, it ran OK for several days and then started to motorboat (ie, it produced a noise from the speaker that sounded like the engine of a motorboat). This usually indicates a faulty electrolytic capacitor and this can be checked by bridging each capacitor in turn with an equivalent value.

In this case, the receiver's operation returned to normal when I bridged the new 8µF capacitor that I'd installed earlier. A faulty new capacitor? No, I'd managed to make a dry solder joint on one of its leads, which was rather embarrassing! Resoldering the joint fixed the problem.

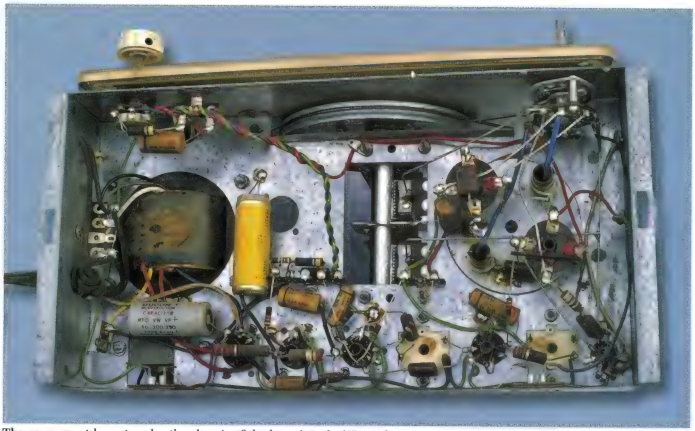
Alignment

This set isn't easy to align, not because it's a difficult procedure but because the IF transformer slugs are well sealed. In addition, all the trimmer capacitors marked with an asterisk (*) on the circuit are in fact made from a thick piece of enamelled copper wire which is overwound with thin enamelled copper wire.

Because the set's performance appeared to be quite satisfactory, I initially decided it would be too much trouble to try to peak the tuning adjustments. In fact, they obviously weren't intended to be altered after they had been set by the manufacturer.

In this set, the oscillator is a little different to normal in that it's shunt fed, with no DC voltage on either of the oscillator coil windings. However, capacitor C3 provides padder feedback to ensure reliable oscillator operation across the band.

As it stood, the IF amplifier was peaked at about 460kHz and I decided to leave it alone. However, the high-frequency end of the tuning range



The component layout under the chassis of the later (5-valve) Precedent receiver was clean and uncluttered. Its chassis is of much better quality than the earlier 4-valve set, although it was still aimed at the lower end of the market.

of the receiver only extended to 1580kHz, so some work was needed here. This involved taking a few turns off each of the oscillator and aerial trimmer capacitors, after which the core of the aerial coil was adjusted at the low-frequency end of the dial. The tuning range was then quite satisfactory and all the expected stations were received.

The sensitivity of the receiver is good at the high frequencies but it's a bit ordinary at the lower frequencies. However, any station worth listening to at my location was quite audible.

Cabinet repair

The techniques described in the article in the July 2001 issue were used to repair the Bakelite cabinet. Fortunately, it was just a matter of fixing the cracks and breaks and no sections had to be fabricated as is sometimes necessary.

Unfortunately, I couldn't get the break in the top of the cabinet to mate, despite using quite a bit of pressure. As a result, I had to glue it first and then apply fibreglass to the underside of the cabinet top. I also scraped out some of the glue on the top of the cabinet and then filled the resulting grooves with fibreglass that had been mixed with some craftwork paint.

Cream isn't an easy colour to match but the finished cabinet looks quite reasonable. And, at least, it won't fall to pieces.

Summary

This cheap, little 4-valve set really was designed for the lower end of the market. As mentioned above, the chassis was only lightly plated and it had rusted badly in spots. In addition, the layout both above and underneath the chassis is rough and ready.

The cost-cutting is evident everywhere. For example, the IF transformers are each made out of a flat piece of metal which has been rolled into a cylinder and the overlapping ends riveted together. And on a similar theme, the transformer windings are on a plastic former which is fitted with top and bottom plastic plates.

The dial system also leaves a bit to be desired. It does work but it's not up to the standard of most other sets.

Does it have any good points? Yes, definitely – it's cheap, its performance is not far behind that of most 5-valve sets and it's easy to dismantle. In fact, it takes less than a minute to remove the chassis from its cabinet.

Try doing that with an AWA "seven bander" – they take nearly half an hour to dismantle or to reassemble.

It's not a set that I'd crawl over hot coals to obtain, however. Instead, it's an interesting low-end receiver that's worthy of collecting, if only to show just how well low-cost receivers can perform.

Finally, it's worth noting that the quality of the Precedent receivers improved markedly in just a few years. For example, I have a 1958 dual-wave 5-valve radiogram chassis and that unit shows a significant improvement in all areas of design and manufacture. The chassis is better quality, the layout of the components and the design is better, the accessibility is improved (it was good beforehand), and the dial mechanism is light years ahead of the 4-valve mantel set's dial-drive system.

The later unit also looked far more professional, although it was still aimed at the lower end of the market. A. W. Jackson Industries and Precedent receivers are a small but important part of our radio heritage. **SC**

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Active crossover as an audio splitter

Would it be possible to use the 3-Way Active Crossover featured in the January 2003 issue so that the "Tweeter out" and "Midrange out" did not have any filters included? I want to use the project as a splitter for one common line in. It will be used to power a DJ system for a club, where there is a set of speakers inside the club (controlled by "Tweeter Out") and a set of speakers outside the club (controlled by "Midrange Out"). I would leave the "Bass Out" for a stereo subwoofer driver inside the club.

I would replace the six trimpots with three 100kΩ (log) dual-gang potentiometers. Then disconnect the leg of the potentiometer that connects to IC1c pin 8 and connect it to IC1a pin 1. Similarly, disconnect the leg of the potentiometer that connects to IC3b pin 7 and connect it to IC1a pin 1. Any suggestions would be appreciated? (D. F., via email).

● Yes, you could but you are effectively wasting four op amps in each channel. Your method of connection is OK. You can leave out the 2.2nF capacitors and 10kΩ feedback resistors for IC1d and IC1c and the 47nF capacitors and 10kΩ feedback resistors for IC3c and IC3b.

Naughty changes to the SC480

I built two SC480 version 1 modules (SILICON CHIP, January & February 2003) and all is well except for the two BC639s and the BC640 which get very hot even with heatsinks. I'm sure I know the reason and that is that I've used a 30-0-30V 300VA toroidal transformer that I've had for a while. It is putting out somewhere in the vicinity of 47V DC. The obvious answer is probably that I need to go back to the 28-0-28V transformer recommended but that leaves me again with this as yet unused toroidal transformer.

Is there any way I can stop those darn critters overheating by changing resistor values or substituting others in their place? I don't want to compromise the design, so if it's no then it's no. (R. C., via email).

● You've been naughty by doing that substitution. You could try substituting BD139/140s for the BC639/640 but component spacing will make this difficult and you will need to fit larger flag heatsinks. Note that the two flag heatsinks *must* be isolated from each other.

Oscillator problem with Smart Card project

I have built the Smart Card Programmer from the January 2003 issue. I have a problem with the clock timing when set to 3.57MHz. I am using a Metex M-3850D multimeter for all measurements. Can you please advise me why the frequency at pin 8 of IC2, the 74HC00, is double that at pin 9. When set to 6MHz, the frequency at pins 6, 11 & 12 are all 5.99MHz, so presumably the problem is around IC2c and X1. (A. H., via email).

● It sounds as if the 3.58MHz crystal in your kit (X1) is especially prone to oscillate on its second harmonic. This being the case, you may need to increase the value of the 1.5kΩ series feedback resistor, to achieve more attenuation at the higher frequency so it is forced to oscillate at the fundamental. Try increasing the resistor to 1.8kΩ or even 2.2kΩ until the frequency measured at pin 8 of IC2 is 3.579MHz.

Config files for EPROM programmer

I have just finished building the Windows-based Eprom Programmer described in the November & December 2002 & February 2003 issues. Have you provided any config files? Could you advise how I get them or create them? (M. J., via email).

● There were a number of config files included in the software package which is available from the SILICON CHIP website. However, it's easy to make up your own config files for other devices: you simply set the program on-screen with the pin connections, programming pulse width, etc from the device manufacturer's data, and

How To Magnetically Shield Loudspeakers

I am looking for information on how to protect my television set from an old pair of Pioneer speaker boxes that are obviously not magnetically shielded.

Is there a way I can shield the boxes by perhaps lining the inside with something or do I need to purchase new ones? The existing speakers sound great and I would like to keep on using them if possible. (T. B., via email).

● There is no easy way that we know of to magnetically shield existing speakers. The system involves an extra magnet and steel cowl assembly to cancel the magnetic field leakage from the main magnet. On the other hand, if your speakers are so old that they use Alnico magnets (rather than the ferrite magnets which have been in use for the last 30 years or more), you may not need any shielding.

How to tell? Suspend a steel paper clip from a 300mm length of cotton and dangle it around the outside of the cabinet on the same level as the speakers. If the paper clip is obviously moved by the magnetic field, make sure you keep the speakers at least 1.5 metres from your TV. You can do the same test with a compass.

Better transistors for the SC480 amplifier

Your SC480 amplifier in the January & February 2003 issues could not have come at a more opportune time. I had bought an Australian-made amplifier some 15 years ago (after much reading of reviews) with the insurance from a robbery in which my Phase Linear 350W RMS per channel amplifier plus Amcron preamp and other assorted pieces of hifi gear were stolen.

The Australian amplifier (approx. $2000) did not last long before one of the channels blew. It was returned to the maker who fixed the problem. The amplifier finally expired a few years later and then the maker was uncontactable. I was faced with the problem of replacing the amplifier boards which were very small and were fixed vertically to the heat-sink.

I also have a defunct Sugden which had seen many years of service (with the replacement of various diodes and resistors) until the PC boards became so burnt and brittle that some of the tracks were hanging in space! Needless to say, despite Sugden's claim of lifetime service, they were unable to replace the amplifier boards and suggested that I buy a new Sugden. So I built two of your 1987 design amplifiers and incorporated them into a rack chassis with the Sugden's huge transformer and capacitor bank. They have given sterling service.

The new SC480 design with the plastic power transistors will fit nicely into the expensive Aussie amplifier which has a more than adequate trannie and capacitor bank. However, I have a couple of questions: (1) Can I use the Motorola MJL21193/4 plastics in place of TIP3055/TIP2955 transistors without modifying the circuit? (2) Is there any sonic advantage in replacing the 1987 design in my "Sugden" with the new SC480 2N3055/MJ2955 amps? (J. W., Carwoola, NSW).

● Yes, you can drop in the MJL-21193/4s without any other modification and they will certainly give an improvement in distortion performance. However, they are very expensive and their potential is a little wasted in this circuit because the SC480's supply voltage is too low to extract the maximum available power. In the Plastic Power modules featured in the April 1996 issue, we got 125W into 8-ohm loads and 175W into 4-ohms (more with Music Power).

As you are aware, the main improvement in performance between the 1987 design and the SC480 is in the very careful PC board design and wiring layout. You should be able to hear the difference but whether it is worth changing to the SC480 boards in your "Sugden" amplifier is up to you.

then save the settings as a config file clicking on File->Save Device Config. The dialog box prompts you for the filename, etc.

Endpoint for Nicad/ NiMH discharging

I'm looking to build a simple discharger circuit for the NiMH cells I use in my digital camera and am curious (given your past projects on dischargers) whether the 0.9V-1V indicated as the end-point for discharging is the open-circuit cell voltage or the cell voltage under load? (J. L., via email).

● The end-point voltage is the voltage under load. Depending on the cell rating, our past discharger circuits would work at around 180mA and measure the cell voltage at this current. Measuring off load gives an erroneous result.

Personal noise source modifications

I've built your Personal Noise Source from the September 2001 issue. I'm trying to use it as a test noise source for sub-woofer tuning and calibration but its output level and frequency response is too low in the 40Hz-150Hz range. Is there anything you can suggest that might correctly modify this kit to fit my need? (L. J., via email).

● The main limiting factor in frequency response will be due to the 470µF capacitor at the speaker output. Into 8Ω, the rolloff is 3dB down at 42Hz. You probably need to increase the capacitor to 2200µF. Also increase the 22µF capacitor between pins 1 and 8 of IC2 to 220µF.

Poor matching in volume control

I own a Playmaster power amplifier and preamp which performs brilliantly, with stunning performance equivalent to commercial equipment costing 2-3 times more. I do have a question regarding the operation of my preamplifier though. With very high line levels and low volume settings, the righthand channel appears to cut in well before the lefthand channel, even though both channels are very similar in amplitude. Why does this happen? This causes problems when listening to stereo music at very low levels. (D. F., via email).

● We assume that you are talking about the operation of the volume control – where rotating it from zero setting causes one channel to cut in before the other. This is caused by poor matching of the resistance tracks of the

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Notes & Errata

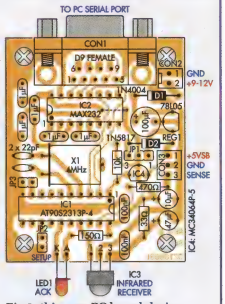
Frequency Meter, October 2003: VR2 on both the circuit and overlay should be 10kΩ. The parts list is correct.

PC Infrared Remote Control, August 2003: Some constructors have reported that the remote power-up function stops working after switching power on and off a number of times. The problem was traced to EEPROM corruption during brownout of the +5V supply to the microcontroller (IC1).

To fix the problem, mount an MC34064P-5 undervoltage sensing IC on the bottom (copper) side of the PC board as shown in Fig.1. If you've yet to assemble your board, then this should be done after all other components have been installed. Slip a short length of heatshrink tubing over the GND lead of the IC before soldering it. This ensures that the GND and +5V leads can't short together.

Fig.1: this diagram shows how to modify existing boards.

The MC34064P-5 is available from Altronics (cat. Z-7252) and Farnell (cat.703-709).



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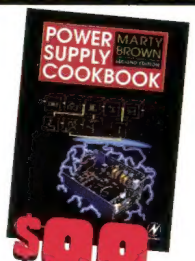

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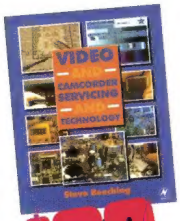

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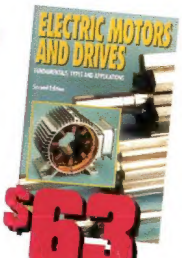

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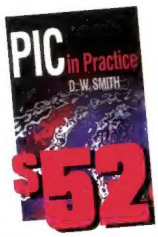

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